The Journal of
Agricultural Economics Research

Vol. 45, No. 4

United States Department of Agriculture

Economic Research Service

A Retrospective Farewell

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The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director, Office of Management and Budget.

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"We can make change our friend
and not our enemy."
—William J. Clinton,
January 20, 1993

The **Journal of Agricultural Economics Research** was founded by O. V. Wells in January of 1949. Throughout the years it has served as a distinguished and path-breaking outlet for applied economic research conducted by the staff of the Economic Research Service, its predecessor agencies, and its many collaborators. A list of past contributors reads like a hall of fame for agricultural economics—Fred Waugh, Karl Fox, John Lee, Neill Schaller, Richard Foote, Willard Cochrane, and Marc Nerlove, to name but a few. Many articles appearing in the journal have not only become classics but have illuminated the path for future generations of researchers. The profession, and indeed society, have been enriched because of the **JAER**'s presence.

Today, forty-six years later, we say farewell. This is our last issue. It is never easy saying goodbye to an old, trustworthy friend, but it falls upon us, the current editors, to perform this responsibility. Yes, the journal is a victim, not of the budget-cutting frenzy so popular today, but rather a casualty of a changing environment in USDA, ERS, and the agricultural economics profession. The well-developed information marketplace serving the profession, coupled with a changing mission at ERS, have determined the **JAER**'s fate.

ERS is in the midst of a transformation. The agency has experienced large budget cuts and is scheduled to be less than half the size it was a decade or so ago. As the agency shrinks and its mission changes, activities once thought to be sacrosanct are no longer viable. Limited resources, both human and non-human, must be redirected to meet new agency priorities and challenges.

Change is inevitable but we believe also manageable. While the **JAER** will cease to exist, its legacy will live on. It is in that spirit that we wish to leave our readers.

This final issue of the journal is devoted to reprinting some of the most noteworthy articles that have graced our pages. Granted, the selection of these articles was highly subjective, but not entirely random or devoid of logic. We tried to pick articles with great depth, innovative for the time, and of interest to a broad range of economists. Gene Wunderlich and Gerald Schluter, former editors of the **JAER**, were especially helpful in making these selections.

The fourteen articles selected address topics ranging from the long-run demand for farm products to analysis of the food stamp program to agricultural production response models. Many of the papers will be immediately recognized, as will all of the authors. We hope our readers enjoy this collection of "the best of the best."

Before leaving we would like to salute the former editors of the journal: Howard Parsons, Caroline Sherman, Herman Southworth, William Scofield, Charles Rogers, James Cavin, Rex Daly, Elizabeth Lane, Ronald Mighell, Allen Paul, Judith Armstrong, Clark Edwards, Raymond Bridge, Lorna Aldrich, Gerald Schluter, and Gene Wunderlich. These are the men and women who made the journal what it was—a first-class publication.

Goodbye.

James Blaylock
David Smallwood

AGRICULTURAL ECONOMICS RESEARCH

A Journal of Economic and Statistical Research in the
Bureau of Agricultural Economics and Cooperating Agencies

Volume III | JULY 1951 | Number 3

Factors Affecting Farm Income, Farm Prices, and Food Consumption

By Karl A. Fox

Agricultural price analysis was one of the hard cores around which the agricultural economics of the 1920's and early 1930's were built. Since then, in all too many cases the working economists have been too busily engaged in current operations to set down their appraisals of price-making forces in any formal way. Many have drifted from recognized statistical methods to a shorter-run, almost wholly intuitive, "market feel" approach. Some of the theoretical or teaching economists, especially the mathematically trained group, have gone in the opposite direction, stressing models, structural equations, and the substitution of symbols for statistics. In one sense this article returns to an earlier tradition, once again substituting statistical values for symbols, and at the same time formally setting down both the methods and the results in such a way that they can be checked, in terms of both theory and experience.

But Fox has gone beyond the earlier tradition in a number of respects. Commodities accounting for a large proportion of farm income are treated in a consistent manner. The marketing system is recognized as a separate entity standing between consumer demand at retail prices and that of processors and dealers at the farm or local level. The statistical methods used are relatively simple, but they have been chosen after careful consideration of the theories and more complex equation forms advanced by the mathematical economists and econometricians. Suggestions are offered as to means of reconciling both family-budget and time-series information relating to the demand for food.

The more technical part of the article is preceded by a discussion of factors affecting the general level of farm income and the demand for farm products as a group.—O. V. Wells

Sources of Cash Farm Income

ONE APPROACH to the subject of demand for farm products is to consider the stream of goods marketed from farms and the ultimate destinations of the components of that stream. A stream of cash receipts flows back to farmers from each of the component flows of goods.

The volume of cash received from a particular source is only an approximate measure of its importance in the determination of farm income. The net effect of each flow of goods depends upon the elasticity of demand for farm products in other uses as well. For example, if there had been no price-support program on corn and cotton in 1948, cash income from commercial sales might have been considerably lower.

In table 1, cash receipts are separated into five components: (1) sales to other farmers, (2) sales to domestic consumers, (3) sales to the U. S. armed forces, (4) sales for export, and (5) net proceeds from price-support loans.

The first of these components, sales to other farmers, is frequently overlooked. In 1949, some

TABLE 1. — *Sources of cash farm income, United States, 1940, 1944, and 1949*

Source	Cash farm income[1]		
	1940	1944	1949
	Bil. dol.	*Bil. dol.*	*Bil. dol.*
1. Sales to other farmers[2]	*0.9*	*2.0*	*3.1*
a. Livestock	0.5*	0.7*	1.4*
b. Feed[3]	0.4	1.3	1.7
2. Sales to domestic consumers	*6.8*	*14.5*	*20.3*
a. Food	• 6.0*	11.7*	18.0*
b. Fibers[4]	0.5	1.1	1.3
c. Tobacco	0.2	0.6	0.7
d. Other[5]	(0.1)	(1.1)	(0.3)
3. Sales for the U. S. armed forces (food only)[6]	------	*1.9*	*0.3*
4. Sales for export[7]	*0.4*	*1.8*	*2.8*
5. Net proceeds from price support loans[8]	*0.3*	*0.2*	*1.6*
Total, all sources	8.4*	20.4*	28.1*

[1] Each stream of goods valued at farm prices. Most of these figures are unofficial estimates. Asterisks denote official estimates (rounded).

[2] Used for further agricultural production.

[3] Fifty-five percent of total farm expenditures for purchased feed in 1944 and 1949; 45 percent in 1940.

[4] Cotton, wool, and mohair.

[5] Net result of (a) sales of miscellaneous nonfood crops, (b) equivalent farm value of hides and other nonfood livestock byproducts, (c) changes in commercial nonfarm stocks, (d) farm income from CCC price-support purchases minus CCC sales which appear in domestic consumption, purchased feed, and exports, and (e) errors of estimation and rounding.

[6] Excluding purchases for civilian feeding in occupied territories.

[7] Including military shipments for civilians in occupied territories.

[8] Net proceeds to farmers from CCC loans. Does not include returns from CCC purchase and disposal operations, as on potatoes.

1,363 million dollars' worth of livestock (mainly feeder and stocker cattle) were sold by one group of farmers, were shipped across State lines, and were bought by other farmers. This represents an internal flow of commodities and money within agriculture, and is not a net contribution from agriculture to other sectors of the economy. Farmers in 1949 also spent 3,080 million dollars for purchased feed. According to rough calculations, approximately 55 percent of this amount, or 1,700 million dollars, was reflected back into cash receipts for other farmers.

The movement of livestock and feed between farmers in 1949 accounted for 3.1 billion dollars, or about 11 percent of total cash receipts from farm marketings. The value of this internal flow is affected by changes in prices of livestock and feeds and by changes in the volume of movement between farms.

The second and by far the largest component of cash receipts is derived from sales to domestic civilian consumers. The total amount of this flow in 1949 was about 20.3 billion dollars. Between 85 and 90 percent of the total (18.0 billion dollars) was from sales of food. Sales of cotton, wool, and mohair, returned 1.3 billion dollars, and sales of tobacco for domestic use 0.7 billion dollars. The other item shown in table 1 under sales to domestic consumers is really a residual from the remaining calculations in the table, and is explained in its footnote 5.

The third component of cash farm income is from sales to the armed forces for the use of our own military personnel. During most of the postwar period, the military has also bought food for relief feeding in occupied territories. As these shipments are included in the value of exports (item 4 of table 1) and as their volume is not directly dependent on the size of the armed forces, they are not included here. Food used by the armed forces represented only about 1½ percent of our total food supplies in 1949. At the height of our war effort in 1944, however, the armed forces required nearly 15 percent of our food supply.

The fourth major component of farm income is from sales to foreign countries, and military shipments for civilian feeding in occupied areas. For several years the volume of exports has been unusually dependent upon programs of the U. S. Government. During 1949, more than 60 percent of the total value of agricultural exports was financed by ECA and military relief feeding programs.

The fifth component is net proceeds to farmers from CCC commodity loans. Under the terms of price-support legislation this is a residual source of income after all commercial demands at the prescribed price-support levels have been satisfied. During 1949, loans taken out by farmers on commodities exceeded farmers' redemptions of such loans by some 1.6 billion dollars. Although this item represented a substantial contribution to cash farm income in 1949, it could well be a negative item in other years. The rapid redemption of cotton of the 1949 crop during the summer of 1950 is an excellent illustration of this.

Table 1 shows that the great bulk of cash farm income is determined by domestic factors. More than 70 percent of total cash receipts come from sales to domestic consumers. The 10 or 11 percent of cash receipts representing sales to other farmers moves with the domestic demand for livestock

products. The volume of food required for our armed forces depends upon governmental decisions. Even sales for export are considerably influenced by domestic factors. This point is developed further in the following section.

Factors Affecting General Level of Farm Income

A number of basic factors must be considered in appraising the outlook for farm income at any given time.

Disposable Income of Consumers. — The disposable income of domestic consumers has proved to be the best over-all indicator of the demand for agricultural products consumed by them. Our livestock products, fresh fruits, and vegetables are consumed almost wholly in this country. Cash receipts from these products are closely associated with year-to-year changes in disposable income. Disposable income affects receipts from such export crops as wheat, cotton, and tobacco, but foreign demand conditions are also highly influential.

Obviously, a key problem in forecasting demand for farm products is to anticipate changes in disposable income. To see the factors that influence this variable, we must place it in a still broader context—that is, the total volume of economic activity of individuals, corporations and Government. Table 2 shows the major components of this total as estimated by the Department of Commerce.

In most years the strategic factors causing changes in disposable income are (1) gross private domestic investment and (2) expenditures of Federal, State, and local Governments. Government expenditures are a substantial factor in the peacetime economy, and the dominant element in time of mobilization or war. Gross private domestic investment includes new construction — residential, commercial, and industrial—expenditures for producers' durable equipment, and changes in business inventories.

The Securities and Exchange Commission has had considerable success in estimating changes in business expenditures for new plant and equipment on the basis of information submitted by businessmen. Actual construction of buildings or delivery of heavy equipment lags several months to a year behind the issuance of contracts or orders. Hence, knowledge of new contracts and orders gives us valuable insights into the level of employment and industrial activity to be expected several months ahead.

Table 2.—*Gross national product, disposable income, and consumer expenditures, United States, 1950*

Item	Amount
	Billions of dollars
A. Expenditure Account	
Gross national product	*279.8*
Government purchases of goods and services	*42.1*
Federal	22.7
State and local	19.4
Gross private domestic investment	*49.4*
Nonfarm residential construction	12.5
Other construction	9.3
Producers' durable equipment	23.4
Change in business inventories	4.1
Net foreign investment	*—2.5*
Personal consumption expenditures	*190.8*
Nondurable goods	*101.6*
Food	[1] 52.2
Tobacco products	4.4
Clothing and shoes	18.7
Other (including alcoholic beverages)	[1] 26.3
Services	*59.9*
Housing	18.3
Other	41.6
Durable goods	*29.2*
Automobiles and parts	12.1
Other	17.1
B. Income Account	
Gross national product	*279.8*
Minus: Business taxes, depreciation allowances, undistributed profits and other items[2]	75.6
Equals: Personal income from current production of goods and services	204.2
Plus: Government transfer payments	19.1
Equals: Total personal income	223.2
Minus: Personal taxes and related payments	20.5
Equals: Disposable personal income	*202.7*
Personal savings	11.9
Personal consumption expenditures	190.8

Source: U. S. Department of Commerce.

[1] Estimated.

[2] Includes capital consumption allowances, indirect business tax and nontax liabilities, subsidies minus current surplus of Government enterprises, corporate profits and inventory revaluation adjustment minus dividends, contributions for social insurance (included in Supplements to wages and salaries) and a statistical discrepancy.

Note: Details will not necessarily add to totals, because of rounding.

Changes in business inventories are an active element in the economy in some years. "Pipe-line" stocks of consumer durable goods were practically zero at the end of World War II, and the pressure to build up working stocks was a significant addition to the final consumer demand. At other times the change in business inventories is a surprise to businessmen themselves. It means that they have been producing or buying at a faster rate than was justified by the existing level of demand. An unplanned increase in business inventories may be followed by a sharp contraction in manufacturers' output, with a consequent reduction in employment

and payrolls in the industries that are overstocked. This, in turn, depresses the demand for consumers' goods, including food.

In 1950, Government purchases and gross private investment amounted to 33 percent of the Gross National Product. The other 67 percent consisted of personal-consumption expenditures. These expenditures are divided into three broad categories. In 1950, services, including rent and utilities, amounted to 59.9 billion dollars. Expenditures for nondurable goods amounted to 101.6 billion dollars, of which about 52 billion dollars went for food. The remaining 49 or 50 billion dollars went for clothing, household textiles, fuel, tobacco, alcoholic beverages, and a wide variety of items. Expenditures for such consumers' durable goods as automobiles and household appliances reached 29.2 billion dollars in 1950.

Under peacetime conditions consumer expenditures are generally regarded as a passive element in the economy, following rather than causing changes in employment and income. Expenditures for food, clothing, and other nondurable goods seem to adapt themselves rapidly to changes in disposable income. Outlays for such services as rent and utilities change more slowly.

Expenditures for consumer durable goods normally fluctuate 1.5 to 2.0 times as much from year to year as does disposable income. In years of low employment, consumers sharply reduce their outlays for new durables and get along on what they have. Toward the top of a business cycle deferred purchases are caught up, so that the rate of new purchases in a year like 1929 (or 1950) is higher than could be maintained indefinitely even under conditions of full employment.

Although expenditures for consumer durables generally move with consumer income, the fact that they *can* be either deferred or advanced makes them a potential hot-spot in the economy. The wave of consumer buying that immediately followed "Korea" is a dramatic illustration. Expenditures for durable goods had been unusually large from 1947 through 1949 and many economists had expected them to slacken in 1950. Actually, the 1950 expenditures for consumer durables were up 22 percent from 1949, with the bulk of the rise concentrated in the second half of the year.

In summary, we may say that year-to-year changes in disposable income depend on the decisions of businessmen (including farm operators), the decisions of consumers, and the decisions of Federal, State, and local Governments. Ordinarily, the strategic decisions are made by business and Government. Although decisions of consumers usually follow changes in disposable income, they may become as influential as the decisions of businessmen in initiating changes at critical junctures. The "potential" of consumer initiative has been increased by the abnormally large holdings of liquid assets by individuals. Installment and mortgage credit give additional scope to consumer initiative in an inflationary period unless curbed by Government action.

Changes in Marketing Margins. — Disposable income is the chief determinant of consumer expenditures for food in retail stores and restaurants. But between consumer expenditures and cash farm income lies a vast, complex marketing system. During 1949, farmers received slightly less than 50 cents of the average dollar spent for food at retail stores. Still higher service charges were involved in food eaten at restaurants. For non-food products, as cotton, wool, and tobacco, farmers received about 15 percent of the consumer's dollar.

Marketing margins for food crops show great variation. Fresh fruits and vegetables grown locally during the summer and fall may move directly from farmers to consumers. In winter, fresh truck crops are transported long distances from such States as California, Texas, and Florida, and the freight bill takes a substantial share of the consumer's dollar.

Grain products undergo much processing between farms and consumers. A loaf of bread is a far different commodity than the pound or less of wheat which is its main ingredient. During the years between World War I and World War II farmers received for the wheat included in a loaf of bread anywhere from 7 to 19 percent of the selling price of the bread itself. Bread includes such other ingredients as sugar and fats and oils, which are also of farm origin, but 70 percent of the retail price of bread in 1949 represented baker's and retailer's charges over and above the cost of primary ingredients.

Meat-animal and poultry products have relatively high values per pound and most of them move through the marketing system in a short time. Farmers receive anywhere from 50 to 75 percent of the retail dollar spent for various food livestock products.

During the period between 1922 and 1941 a change of 1 dollar in retail food expenditures from year to year was usually associated with a change of 60 cents in farm cash receipts. But during World War II, marketing margins were limited by price-control and other measures, so that from 1940 through 1945 farm income from food products increased 78 cents for each dollar increase in their retail-store value. Following the removal of subsidies and special wartime controls in 1946, marketing margins for farm products rapidly "reflated." From 1946 to 1949 the national food marketing bill increased more than twice as much as did farm income from food products. Farmers got only 26 percent of the increase in retail food expenditures.

The mild recession of 1949 seemed to presage a return to the prewar relationship between changes in consumer food expenditures and farm cash receipts. If so, it has probably been disturbed again by the advent of mobilization and price control.

Cotton and wool are elaborately processed and may change hands several times before reaching the final consumer. The manufacturing and distributing sequence takes several months. Tobacco is stored for 1 to 3 years before manufacture. Excise taxes absorb close to 50 cents of the consumer's dollar spent for tobacco products. The marketing processes for these products are so expensive and time-consuming that short-run changes in their retail prices may show little relationship to concurrent price changes at the farm level.

Government Price Supports. — Domestic demand for such commodities as wheat, cotton, and tobacco is rather inelastic. Consumption varies little from year to year in response even to drastic changes in their farm prices. Therefore, Government loans have become extremely influential in maintaining farm income from these crops in years of large production.

Ordinarily Government price-support programs may be regarded as a passive factor in the demand for farm products, once the level of support has been prescribed by legislation or administrative decision. The loan program stands ready to absorb and hold any quantities that cannot be marketed in commercial channels, either domestic or export.[1] Government purchases under Section 32 of the Agricultural Adjustment Act have been of strategic importance in relieving temporary gluts of perishable commodities.

Export Demand.—At first glance it might appear that the demand for our agricultural exports is completely independent of decisions made in our own country. But foreign buyers must have means of payment, typically dollars or gold. United States imports of goods and services are usually by far the largest source of such means of payment. Our imports from other countries are closely geared to the disposable income of our consumers and to the level of industrial production. Prices of industrial and agricultural raw materials usually respond sharply to increases in demand. In consequence, the total value of our imports is closely correlated with our gross national product and disposable income. During the 1920's and 1930's nearly 75 percent of the year-to-year variation in the total value of our exports was associated with changes in disposable income in the United States.

In the postwar period, loans and grants by the Government have been of tremendous importance in determining our agricultural exports. During 1949 some 60 percent of the total value of our agricultural exports was financed from appropriations for ECA and for civilian feeding in occupied countries.

There are many independent elements in the demand from abroad for our agricultural commodities. Unusually large crops in importing countries in a given year reduce their import requirements. An increase in production in other exporting countries also reduces the demand for our products. The effect of supplies in competing countries has been even more direct in the postwar years of dollar shortages than it was before World War II.

Factors Affecting Prices of Farm Products

During the last few months the author has developed statistical demand analyses for a considerable number of farm products. Practically all of these analyses are based on year-to-year changes in prices, production, disposable income, and other relevant factors, during the period between 1922 and 1941.

Price ceilings and other controls cut across these relationships during World War II and may well do so again during this mobilization period. But 1922-41 relationships are in most cases still the best bases we have for appraising short-run movements

[1] Subject to restrictions on eligibility for price support, such as compliance with marketing quotas or acreage allotments.

in, or pressures upon, the price structure. In practical forecasting, new elements which arise during the mobilization period must be given weight in addition to the variables included in our prewar analyses.

Method Used

Considerations of space make it necessary to assume that most readers are familiar with the statistical method by which the results of this section were derived. The method used was multiple regression (or correlation) analysis using the traditional least squares, single-equation approach. The recent development of a more elaborate method by the Cowles Commission of the University of Chicago necessitates a few words in explanation of the author's procedure.

In general, demand curves for farm products that are perishable and that have a single major use can be approximated by single-equation methods.[2] Most livestock products and fresh fruits and vegetables (and, pragmatically, feed grains and hay), fall in this category. Such products contribute more than half of total cash receipts from farm marketings. With other farm products—as wheat, cotton, tobacco, and fruits and vegetables for processing—two or more simultaneous relationships are involved in the determination of free-market prices. The multiple-equation approach of the Cowles Commission may be fruitful in dealing with such commodities. Even in the case of wheat or cotton, however, it is possible to approximate certain elements of the total demand structure by means of single equations.

The demand curves shown in this section have been fitted by single-equation methods after considering the conditions under which each commodity was produced and marketed. Commodities with complicated patterns of utilization have been treated partially or not at all.

The functions selected were straight lines fitted to first differences in logarithms of annual data. In most cases, retail price was taken as the dependent variable and per capita production and per capita disposable income undeflated as the major independent variables. To adapt the results to the requirements of a mobilization period in which consumption or retail price, or both, are controlled variables, per capita consumption was substituted for production in some analyses. Further adjustments were made in a few cases for the purpose of comparing net regressions of consumption upon (deflated) income with the results of family-budget studies.

The logarithmic form was chosen on the ground that price-quantity relationships in consumer demand functions were more likely to remain stable in percentage than in absolute terms when there were major changes in the general price level. First differences (year-to-year changes) were used to avoid spurious relationships due to trends and major cycles in the original variables, and for their relevance to the outlook work of the Bureau of Agricultural Economics which focuses on short-run changes.

Before World War II, commodity analysts frequently expressed the farm price of a commodity as a function of its production and some measure of consumer income. But consumers respond to retail prices. It will contribute to clear thinking if we derive one set of estimating equations relating retail prices and consumer income, and another set expressing the relationships between farm and retail prices. At certain periods, sharp readjustments may take place within the marketing system. For this reason, an equation that expresses farm price as a function of consumer income would have missed badly during 1946-49. We should not have known whether its failure was due to changes in consumer behavior or to changes in the marketing system, as both were telescoped into a single equation.

Results Obtained

FOOD LIVESTOCK PRODUCTS. — Some consumer-demand curves for livestock products are summarized in table 3. A 1-percent increase in per capita consumption of food livestock products as a group was associated with a decrease of more than 1.6 percent in the average retail price. The relationships in table 3 are based on year-to-year changes for the 1922-41 period.

Two sets of relationships are shown in the case of meat. During the early and middle 1920's we exported as much as 800 million pounds of pork in a year. The export market tended to cushion the drop in prices of meat when there was an increase in hog slaughter. As total meat production was

[2] For a fuller treatment of this point and for a brief account of the history and present status of agricultural price analysis see the author's paper, RELATIONS BETWEEN PRICES, CONSUMPTION AND PRODUCTION, *American Statistical Association. Journal*, September 1951.

TABLE 3.—*Food livestock products: Factors affecting year-to-year changes in retail prices, United States, 1922-41*

Commodity or group	Coefficient of multiple determination[1]	Effects of one percent changes in: Production or consumption[2]		Disposable income[2]		Supplies of competing commodities[2]	
		Net effect	Standard error	Net effect	Standard error	Net effect	Standard error
		Percent[3]		*Percent*[3]		*Percent*[3]	
All food livestock products[4]	.98	−1.64	(.13)	0.84	(.03)		
All meat (production)	.98	−1.07	(.07)	.86	(.07)		
Pork	.92	− .85	(.09)	.93	(.10)		
Beef	.96	− .83	(.09)	.83	(.05)	[5]−.38	(.05)
Lamb	.91	− .34*	(.15)	.78	(.07)	[5]−.40	(.11)
All meat (consumption)	.98	−1.50	(.08)	.87	(.03)		
Pork[4]	.97	−1.16	(.07)	.90	(.06)		
Beef[4]	.95	−1.06	(.12)	.88	(.06)	[6]−.52	(.09)
Lamb[4]	.94	− .50*	(.14)	.78	(.06)	[6]−.65	(.14)
Poultry and eggs:							
Chickens[4]	.86	− .75*	(.18)	.76	(.09)	[7]−.42	(.16)
Turkeys (farm price)	.90	−1.21	(.25)	1.06	(.20)	[8]−.97	(.48)
Eggs (adjusted)	.87	−2.34*	(.44)	1.34	(.13)		
Dairy products:							
Fluid milk	.87			.55	(.05)		
Evaporated milk	.84			.59	(.06)		
Cheese	.84			.77	(.08)		
Butter	.84			1.01	(.11)		

[1] Unadjusted. Represents the percentage of total year-to-year variation in retail price during 1922-41 which was "explained" by the combined effects of the other variables.
[2] Per capita basis.
[3] Coefficients based on first differences of logarithms. Can be used as percentages without serious bias for year-to-year changes of as much as 10 or 15 percent in each variable.
[4] Based on *consumption* per capita. Other analyses based on production per capita.
[5] Production per capita, all other meats.
[6] Consumption per capita, all other meats.
[7] Consumption per capita, all meat.
[8] Production per capita, chickens.
* Probably understates true effects of changes in production or consumption upon price.

fairly stable to begin with, small absolute changes in exports, imports, and cold-storage holdings, substantially reduced the percentage fluctuations in consumption of meat. During the 1922-41 period as a whole, meat consumption changed only about 70 percent as much from year to year as did meat production.

The first set of price-quantity coefficients for meat indicates that a 1-percent increase in meat production caused a decline of little more than 1 percent in the average retail price of meat. Increases of 1 percent in pork or beef production were associated with declines of less than 1 percent in their retail prices, and the net effect of lamb and mutton production upon the price of lamb was even smaller.

In a mobilization period the total civilian supply of meat is subject to control. The second set of meat analyses is more relevant to our current situation. A 1-percent decrease in per capita consumption of meat was associated with an increase of 1.5 percent in its average retail price.[3] A 1-percent change in the consumption of pork alone was associated with an opposite change of about 1.2 percent in its retail price. An increase in supplies of pork also had a significant depressing effect on the prices of beef and lamb.

A 1-percent increase in the consumption of beef was associated with slightly more than a 1-percent decrease in its retail price, if supplies of other meats remained constant. If the supply of other meats also increased 1 percent, the price of beef tended to decline another 0.5 percent. Supplies of beef and pork seem to have had fully as much in-

[3] In an inflationary period, commodity prices rise more rapidly than would be indicated by prewar relationships. This does not mean that the price elasticities of demand have changed. The disturbing factors are more likely to affect the relationship between price and consumer income.

TABLE 4.—*Food livestock products: Relationships between year-to-year changes in farm price and retail price, United States, 1922-41*

Commodity or group	Coefficient of determination	Effects of 1-percent changes in: Retail price — Effect	Retail price — Standard error	Other factors — Net effect	Other factors — Standard error
		Percent[1]		Percent[1]	
All food livestock products	.97	1.47	(.07)		
Meat animals—all	.91	1.57	(.12)		
Hogs (1)	.86	1.75	(.17)		
Hogs (2)	.87	1.35	(.44)	[2]0.28	(.29)
Beef cattle	.91	1.74	(.14)		
Lambs	.85	1.06	(.18)	[3] .26	(.05)
Poultry and eggs:					
Chickens	.93	1.35	(.09)		
Eggs	.97	1.08	(.05)		
Dairy products:					
Milk for fluid use	.93	1.64	(.11)		
Condensery milk	.79	2.13	(.27)		
Milk for cheese	.79	1.76	(.22)		
Butterfat	.95	[4]1.35	(.06)		
Creamery milk	.95	[4]1.19	(.08)	[5] .13	(.04)

[1] Coefficients based on first differences of logarithms.
[2] Wholesale price of *lard* at Chicago. Coefficient not significant owing to high intercorrelation ($r^2 = .85$) between retail price of pork and wholesale price of lard.
[3] U. S. average farm price of *wool*.
[4] Coefficient derived by algebraic linkage of two regressions: (1) Farm price upon wholesale price of butter and (2) wholesale price upon retail price. Coefficients of determination have been reduced and the standard error increased to allow for residual errors in both equations.
[5] Wholesale price of dry nonfat milk solids (average of prices for both human and animal use).

fluence on the price of lamb as did the supply of lamb itself.

Increases of 1 percent in supplies of chicken and turkey have depressed their retail prices by about the same amount. The price of chicken was significantly affected by supplies of meat, and the price of turkey was significantly affected by supplies of chicken. It is evident from these two relationships that supplies of meat were also a factor in the determination of prices for turkey. In a special analysis not shown in table 3, supplies of pork during October-December appeared to have a significant effect upon the farm price of turkeys.

The retail price of eggs responded more sharply to changes in production than did prices of any of the livestock products previously mentioned. The change of —2.3 percent (table 3) probably understates the true effect of a 1-percent change in per capita egg production. For reasons discussed later, no price-production relationships are shown for dairy products.

If we turn briefly to the price-income relationships in table 3 we find that many of the coefficients run between 0.8 and 1.0. If we had an adequate retail-price series for turkeys, the regression of retail price upon disposable income would probably be somewhat less than 1.0. Prices of eggs appeared to respond more sharply to changes in consumer income than did those of other livestock products.

There are many difficulties in price and consumption analysis for dairy products. All of these products stem from the same basic flow of milk. The fluid milksheds are only partially insulated from the effects of supplies and prices of milk in other areas. Surpluses from these milksheds are converted into manufactured products, thereby affecting prices of manufacturing milk and butterfat.

In the major manufacturing milk areas there are at least three alternative outlets for milk. Competition between condenseries, cheese factories, and creameries (including "butter-powder" plants), keeps prices of raw milk in the different uses approximately equal. The retail price of each product reflects the common price of manufacturing milk plus processing margins and mark-ups. Dairy products which have wide dollars-and-cents margins show a small percentage relationship between retail price and consumer income. Butter has a small processing and distributive cost relative to its value and shows a sharper "response" of retail price to disposable income.

Table 4 shows some relationships between year-to-year changes in retail prices and associated

changes at the farm level. The coefficients are all in percentage (logarithmic) terms.

It has long been recognized that farm prices fluctuate more violently than retail prices because of the presence of fixed costs or charges in the marketing system. The coefficients in table 4 bear out this observation. Prices of livestock products as a group, during 1922-41, were approximately 1.5 times as variable (in percentages) at the farm level as at retail. The relationships for hogs, beef cattle, and for meat animals as a group ranged from 1.5 to 1.75 percent. The relationship for chickens was about 1.35 percent. The percentage change in the farm price of eggs was only slightly larger than the percentage change at retail.

Farm prices of milk and butterfat fluctuate considerably more than do retail prices of the finished products. Butter has the smallest marketing margin and the smallest percentage relationship between farm and retail price changes. The farm price of fluid milk changed about 1.6 times as sharply as the retail price and the price of milk used for cheese fluctuated about 1.8 times as much as the retail price of cheese. The price paid for milk by condenseries fluctuated more than twice as sharply as the retail price of evaporated milk, owing to the importance of fixed costs and charges in the marketing system.

At least three of the commodities listed in table 4 have important byproducts. Thus, the price of wool is a highly significant factor affecting prices received by farmers for lambs. The price of lard is a recognized factor in market prices for hogs, including price discounts for heavier animals. However, since the wholesale price of lard during 1922-41 was highly correlated with the retail price of pork, the coefficient that relates hog prices to the price of lard is not statistically significant. The price of whole milk delivered to creameries is significantly related to the price of dry nonfat milk solids, as well as to the price of butter.

Other commodities shown in the table have byproducts of some value, including hides and skins. The value of these byproducts is undoubtedly reflected in market prices to some extent and enters into the calculations of processors. But it is not always possible to measure these relationships from time series.

Table 5 summarizes relationships between farm prices, production and disposable income. In most cases the effect of a 1-percent change in production or consumption per capita is associated with more than a 1-percent change in the farm price. There is some indication that the price of hogs during April-September is less sharply affected by changes in pork production than during the heavy marketing season, October-March. Prices of eggs respond more sharply to changes in production than do prices of other livestock products. The price-quantity coefficients for individual dairy products have little significance. The regressions of consumption upon price shown in table 6 are more meaningful and are considered later.

For most livestock products the response of farm price to disposable income is more than 1 to 1. Coefficients seem to center around 1.3. Exceptions to this are prices received by farmers for all dairy products and for wholesale milk, where the coefficients are approximately 1.0.

As in table 3, supplies of competing commodities influence the farm prices of beef cattle, calves, lambs, chickens, and turkeys. The price of dry nonfat solids is again included as a factor affecting the farm price of creamery milk.

Food Crops and Miscellaneous Foods.—Table 5 also shows factors affecting farm prices of several fruits and vegetables. Prices of some of the deciduous fruits responded less than proportionately to year-to-year changes in production. The response for apples averaged —.8 percent, and for peaches (excluding California) approximately —.7. Peaches in other States are produced mainly for fresh market, whereas half or more of the California peaches are clingstone, produced for canning. In California, freestone peaches also are used extensively for canning and drying. Because of the complex utilization pattern, no single estimating equation for California peaches is likely to yield meaningful results.

Before 1936, about 90 percent of all cranberries were marketed in fresh form. Marketings were confined to the fall. A bumper crop in 1937 caused a sharp expansion in processing, and this utilization continued to increase. There is some evidence in the data for later years that the demand for cranberries has become somewhat more elastic as a result. That is, the farm price has been somewhat less responsive to changes in production than it was during the 1922-36 period. On the debit side, farm prices have been depressed in some recent years by excessive carry-overs of processed cranberries.

Prices of citrus fruits responded more than pro-

TABLE 5.—*Factors affecting year-to-year changes in farm prices, United States, 1922-41*

Commodity or group	Coefficient of multiple determination	Effect of 1-percent changes in:					
		Production or consumption		Disposable income		Supplies of competing commodities	
		Net effect	Standard error	Net effect	Standard error	Net effect	Standard error
		Percent[1]		*Percent*[1]		*Percent*[1]	
				Food Livestock Products (per capita basis)			
All food livestock products[2]	.95	—2.45	(.31)	1.23	(.07)		
All meat animals (production)	.88	—1.60	(.26)	1.43	(.15)		
Hogs—cal. yr.	.82	—1.54	(.26)	1.63	(.28)		
Hogs—Oct.-Mar.	.81	—1.52	(.26)	2.08	(.28)		
Hogs—Apr.-Sept.	.69	— .99*	(.25)	1.50	(.37)		
Beef cattle	.90	—1.19	(.23)	1.27	(.13)	[3]— .40	(.15)
Veal calves	.93	— .82	(.16)	1.30	(.10)	[3]— .75	(.16)
Lambs	.87	—1.50	(.31)	1.09	(.15)	[3]— .70	(.24)
Poultry and eggs:							
Chickens	.86	— .62*	(.28)	1.06	(.12)	[4]—1.01	(.30)
Turkeys	.90	—1.21	(.25)	1.06	(.20)	[5]— .97	(.48)
Eggs (adjusted)	.82	—2.91*	(.55)	1.43	(.17)		
Dairy products:							
All	.87			.98	(.09)		
Milk, wholesale	.88			1.05	(.10)		
Milk, fluid use[6]	.91	—1.49	(.42)	.79	(.07)		
Condensery milk[6]	.76	[7]— .41	(.47)	1.34	(.19)		
Milk for cheese[6]	.71	[7]—1.01	(.59)	1.47	(.23)		
Butterfat[6]	.85	[7]—1.13	(.55)	1.28	(.15)		
Creamery milk	.79			[8]1.21	(.14)	[9] .13	(.04)
				Fruits and Vegetables (per capita basis unless otherwise noted)			
All fruits (total)	.82	— .94	(.12)	1.06	(.21)		
All deciduous fruits (total)	.82	— .68	(.09)	1.08	(.18)		
Apples (total)	.96	— .79	(.04)	1.04	(.12)		
Peaches (total)[10]	.80	— .67	(.09)	.96	(.30)		
Cranberries (1932-36)[11]	.86	—1.49	(.19)	.78	(.31)		
All citrus fruits (total)	.92	—1.32	(.10)	.98	(.20)		
Oranges	.93	—1.61	(.11)	1.34	(.25)		
Grapefruit	.72	—1.77	(.28)	1.29	(.55)		
Lemons, all	.61	—1.69	(.34)	[12] .78	(.59)		
Lemons shipped fresh:						Temperature	
Summer[13]	.79	—2.48	(.40)	1.07	(.30)	[14] .98	(.17)
Winter[13]	.88	—1.39	(.16)			[15]—1.69	(.37)
Potatoes	.93	—3.51	(.26)	1.20	(.33)		
Sweetpotatoes	.75	— .77	(.16)	.89	(.24)		
Onions:							
All[16]	.89	—2.27	(.20)	1.00	(.29)		
Late summer[16]	.85	—2.90	(.32)	[17] .72	(.60)		
Truck crops for fresh market[18]							
Calendar year (total)	.85	—1.03*	(.26)	.81	(.12)		
Winter (total)	.67	—1.13*	(.35)	.92	(.31)		
Spring (total)	.49	[17]— .95*	(.48)	.63	(.22)		
Summer (total)	.87	—1.72	(.34)	1.23	(.19)		
Fall (total)	.84	—1.67	(.35)	.85	(.20)		

[1] Coefficients based on first differences of logarithms. [2] Consumption per capita (index). [3] Production per capita, other meats. [4] Consumption per capita, all meat. [5] Production per capita, chickens.

[6] Equations include per capita consumption of end product.

[7] These coefficients do not have "structural" significance, and two of them are statistically nonsignificant also.

[8] Coefficient obtained by algebraic linkage of three equations. Coefficient of determination reduced and standard error increased to allow (approximately) for residual errors in all three equations.

[9] Wholesale price of dry nonfat milk solids (average of prices for both human and animal use).

[10] United States, excluding California.

[11] Processing outlet expanded rapidly after 1937. There is evidence that demand is now more elastic.

[12] Nonsignificant.

[13] Adapted from analyses originally developed by George M. Kuznets and Lawrence R. Klein in "A Statistical Analysis of the Domestic Demand for Lemons, 1921-1941," Giannini Foundation of Agricultural Economics, Mimeographed Report No. 84, June 1943. Prices are measured at the f.o.b. level. The adaptations consist in (1) converting all variables into logarithmic first differences (year-to-year changes), and (2) substituting disposable personal income for nonagricultural income. The latter adjustment had little effect on the results.

[14] Index of summer temperatures in major U. S. cities (Kuznets and Klein).

[15] Index of winter temperatures in major U. S. cities (Kuznets and Klein).

[16] Analysis developed by Herbert W. Mumford, Jr. [17] Nonsignificant at 5 percent level. [18] Equations fitted to 1928-41 data only. * Probably understates true effect of production on price.

portionately to changes in production. The regression coefficients for oranges, grapefruit, and lemons, individually ranged from —1.6 to —1.8 percent. Adaptations of analyses originally developed by Kuznets and Klein suggest that prices of lemons respond much more sharply to year-to-year changes in fresh-market shipments during the summer than during the winter.

The regressions of farm prices upon disposable income center around 1.0. As in most of the analyses the price-income coefficient is not so accurately established as the price-production coefficient, little significance can be attached to deviations above or below 1.0 in the former.

Kuznets and Klein introduced an interesting feature into their analyses—an index of temperatures in major consuming centers. Temperature appears to be a highly significant factor in both summer and winter. Hot weather in the summer increases the demand for lemons in thirst-quenching drinks. On the other hand, unusually cold weather in the winter appears to increase the demand for lemons; the reputation of lemon juice as a preventive of colds may be influential.

Prices of potatoes and onions respond rather sharply to changes in production. In the prewar period, when there were no price-support programs of consequence for potatoes, a 1-percent change in potato production per capita was associated with a 3.5-percent opposite change in the U. S. farm price. Prices of the late summer crop of onions, from which most of our storage supplies come, showed a price-production response of approximately —2.9. The 12-month average price of onions indicates a less violent response to changes in production, or about —2.3.

The analyses for fresh-market truck crops are based on indices of prices and production recently developed by Herbert W. Mumford, Jr. These indices have not yet been thoroughly tested. The correlations between price and production in the summer and fall look reasonable. They indicate a price response to production of about —1.7 percent. The analyses for the winter and spring are not so accurately established. It seems probable that the true response of price to production in these seasons and for the calendar year as a whole is somewhat greater than is implied by table 5.

The regressions of farm prices of vegetables upon disposable income in table 5 center around 1.0. The standard errors of these coefficients are, in general, sufficiently large that the deviations from 1.0 are not significant.

Responses of Consumption to Price.—Table 6 summarizes responses of the consumption of various food livestock products to changes in retail price and disposable income. These coefficients are estimates of the elasticity of consumer demand. For food livestock products as a group, elasticity of demand during 1922-41 seems to have been slightly more than —.5.[4] The elasticity of demand for all meat appears to have been slightly more than —.6. Demand elasticities for individual meats, assuming that supplies of other meats remained constant, ranged from —.8 for pork and beef to at least —.9 for lamb. It is possible that the true elasticity of demand for lamb (with supplies of other meats held constant) was somewhat more than —1.0.

For certain technical reasons the elasticities of demand for chicken and turkey at retail are probably higher than the least-squares coefficients in table 6. The coefficient for turkey is based on farm prices and the response of consumption to a 1-percent change in retail price would certainly be somewhat larger. It seems probable that the elasticities of consumer demand for both chicken and turkey were not far from —1.0 during the 1922-41 period.

The elasticity of demand for eggs is estimated at —.26. It is the least elastic of the livestock products included in table 6 with the possible exception of fluid milk and butter.

The demand elasticities for individual dairy products are not so accurately established as are those for meat and poultry products. There is some evidence that the elasticity of demand for fluid milk (based on year-to-year changes) is about —.3. The elasticity of demand for evaporated milk may be as high as —1.0 although the standard error of this coefficient is fairly large. The only statistically significant coefficient obtained for butter consumption indicated a demand elasticity of about —.25 during 1922-41. Even if this result is correct it seems probable that the consumption of butter under present conditions would respond more sharply than this to changes in price. The increasing use of oleomargarine as a bread-spread is the main reason for this belief.

Table 7 summarizes coefficients for fruits and vegetables which, in general, may be taken as ap-

[4] The words "more" or "less" applied to demand elasticities in this article refer to absolute values. In this case, the estimated elasticity is between —.5 and —.6.

Table 6.—*Food livestock products: Factors affecting year-to-year changes in per capita consumption, United States, 1922-41*

Commodity or group	Coefficient of determination	Effects of 1-percent changes in: Retail price		Price of all other commodities		Disposable income[1]		Supply of competing commodities[1]	
		Net effect	Standard error	Net effect	Standard error	Net effect	Standard error	Net effect	Standard error
		Percent[2]		*Percent*[2]		*Percent*[2]		*Percent*[2]	
All food livestock products:	*Multiple*								
Actual income	.91	—.56	(.04)			0.47	(.04)		
Deflated income	.95	—.52	(.03)	[3] .70	(.10)	[4] .40	(.03)		
All meat:									
Actual income	.96	—.64	(.03)			.56	(.04)		
Deflated income	.96	—.62	(.04)	[5] .69	(.15)	[4] .51	(.05)		
Pork	.94	—.81	(.05)			.72	(.07)		
Beef	.86	—.79	(.09)			.73	(.08)	[6] —.41	(.09)
Lamb	.59	—.91*	(.26)			.65	(.23)	[6] —.83	(.20)
Poultry and eggs:	*Partial*								
Chicken	.54	—.72*	(.17)						
Turkey (farm price)	.74	[7] —.61*	(.13)						
Eggs	.48	[7] —.26	(.07)						
Dairy products:									
Milk for fluid use (farm price)	.44	—.30	(.08)						
Evaporated milk	.28	—.84	(.32)						
Butter	.21	[8] —.25	(.12)						

[1] Per capita basis.
[2] Coefficients based on first differences of logarithms.
[3] Special index, retail prices other than food livestock products.
[4] Disposable income deflated by retail price index.
[5] Special index, retail prices other than meat.
[6] Consumption per capita, other meats.
[7] Production per capita.
[8] Based on algebraic linkage of three equations. Elasticity of demand for butter has probably increased in recent years.
* Probably understates true effect of price upon consumption.

proximations to the elasticity of dealer demand. This is strictly true only if production and sales are exactly equal. These coefficients can also be used as a basis for estimating elasticities of demand at retail if (1) supplies actually reaching consumers are nearly equal to production and (2) if we have appropriate equations relating percentage changes in prices at retail and farm levels. If there are any fixed elements in the marketing margin, the elasticity of demand at the consumer level will be greater than at the farm price or dealer level.

The demand for apples and peaches at the farm-price level was moderately elastic, averaging about —1.2. The demand for cranberries before 1936 was moderately inelastic (about —.6). The elasticity of —1.1 for deciduous fruits as a group was a weighted average for an extremely heterogeneous group of commodities, including fruits used for processing. Apples carried a heavier weight than any other deciduous fruit and contributed largely both to the regression coefficient and to the coefficient of partial determination for the deciduous group as a whole.

Demand elasticities for individual citrus fruits at the packinghouse door appear to have ranged from —.6 down to —.3. Demands for oranges and winter lemons were the most elastic, grapefruit was of intermediate elasticity, and summer lemons had the least elasticity. Processing outlets for citrus fruits have expanded greatly over the last 15 years. Processing has extended the marketing season and increased the variety of product for each of the citrus fruits. On logical grounds, at least, this should have increased the elasticity of demand for them at the farm level. Consequently, the elasticities in table 7 should not be applied to the current situation without careful statistical and qualitative

TABLE 7.—*Fruits and vegetables: Net regressions of production upon current farm price, United States, 1922-41* [1]

Commodity or group	Coefficient of partial determination	Net regression of production upon farm price [2]	
		Coefficient	Standard error
		Percent [3]	
All fruits (total)	.77	—.82	(.11)
Deciduous fruits (total)	.76	—1.11	(.15)
Apples (total)	.96	—1.21	(.06)
Peaches [4] (total)	.79	—1.18	(.15)
Cranberries (1922-36) [5]	.85	—.57	(.07)
All citrus fruits	.91	—.69	(.05)
Oranges	.92	—.58	(.04)
Grapefruit	.70	—.40	(.06)
Lemons, all	.59	—.35	(.07)
Lemons shipped fresh:			
Summer [6]	.72	—.29	(.05)
Winter [6]	.85	—.61	(.07)
Potatoes — production	.92	—.26	(.02)
Potatoes — consumption [7]	.81	—.22	(.03)
Sweetpotatoes	.57	—.74	(.16)
Onions — all [8]	.88	—.39	(.03)
Onions — late summer [8]	.83	—.28	(.03)
Truck crops for fresh market [9]			
Calendar year (total)	.61	—.59	(.15)
Winter (total)	.51	—.45	(.14)
Spring (total)	.28	[10] —.30	(.15)
Summer (total)	.72	—.42	(.08)
Fall (total)	.69	—.41	(.09)

1 If consumption is nearly equal to production, these coefficients may be taken as approximations to the elasticity of *dealer* demand. Demand at the consumer level will typically be more elastic than at the farm or f.o.b. level.
2 Production per capita unless otherwise noted.
3 Based on first differences of logarithms.
4 United States, excluding California.
5 Processing expanded rapidly after 1936. There is some evidence that demand is now more elastic.
6 Adapted from data and analyses originally developed by George M. Kuznets and Lawrence R. Klein, Giannini Foundation, 1943. (See table 5, footnote 4).
7 Response of per capita consumption to retail price.
8 Analysis developed by Herbert W. Mumford, Jr.
9 Equations fitted to 1928-41 only.
10 Unrounded coefficient not significant at 5-percent level.

study of recent experience. In particular, the phenomenal expansion of frozen concentrated orange juice since 1948 may have had a substantial effect on the elasticity of demand for oranges.

During 1922-41, the elasticity of demand for potatoes at retail seems to have been little more than —.2. The extremely inelastic demand contributes to price-support difficulties for this crop, for relatively small surpluses have a considerable depressing effect on both retail and farm prices. The elasticity of demand for onions at the farm-price level appears to have been —.3 or less for the late summer crop, and about —.4 for the year as a whole.

The elasticity of demand for sweetpotatoes is less meaningful than those for potatoes and onions. Some 50 or 60 percent of all sweetpotatoes produced are used on the farms where grown. The elasticity of market demand may be decidedly different from the production-price coefficient in table 7.

Elasticities of demand for fresh-market truck crops seem to center around —.4 at the farm-price level. These coefficients are based on indexes which include a heterogeneous group of commodities. For example, the indexes include onions for which the demand elasticity in late summer and fall was —.3 or less. Implicitly, it appears that demand elasticities for some individual truck crops may be considerably higher than —.4 if supplies of competing truck crops are held constant. The analyses for fresh-market truck crops are little more than exploratory. More detailed analyses for individual commodities will be made as time permits.

TABLE 8.—*Feed grains and hay: Factors affecting year-to-year changes in farm prices, United States, 1922-41*

Commodity	Coefficient of multiple or simple determination	Effect of changes of 1-percent in:			
		Supply factors		Demand factors	
		Net effect	Standard error	Net effect	Standard error
	Multiple	*Percent* [1]		*Percent* [1]	
Hay	.89	−1.39	(.15)	[2] 0.83	(.16)
Corn	.85	[3] −1.93	(.21)	[4] .89 [5] 2.26	(.20) (.71)
Corn	.82	[6] −1.26 [7] − .89	(.28) (.40)	[8] 1.06	(.25)
Corn	.85	[6] −1.22 [9] − .82 [10] +1.72	(.27) (.29) (1.19)	[8] .89	(.25)
		Average percent change in price associated with one percent change in price of corn			
	Simple	Percent change [1]		Standard error	
All feed grains: Prices received by farmers	.99	.91		(.02)	
Hominy feed (Chicago)	.97	.86		(.03)	
Prices paid by farmers for purchased feed	.91	.55		(.04)	
Grain sorghums	.88	.97		(.09)	
Oats	.82	.73		(.08)	
Barley	.77	.68		(.09)	
Soybean meal (Chicago)	.67	.59		(.13)	
Hay	.51	.40		(.09)	
Tankage (Chicago)	.35	.41		(.13)	

[1] Coefficients based on first differences of logarithms.
[2] Cash receipts from beef cattle and dairy products, weighted approximately in proportion to total hay consumption by each type of cattle.
[3] Total U. S. supply of corn, oats, barley and grain sorghums.
[4] Index of prices received by farmers for grain-consuming livestock (weighted according to grain requirements).
[5] Number of grain-consuming animal units on farms, January 1.
[6] U. S. supply of corn (adjusted for net changes in CCC stocks).
[7] U. S. supply of other feed grains and byproduct feeds.
[8] Product of numbers and prices of grain-consuming livestock.
[9] U. S. supply of oats, barley and grain sorghums, plus wheat and rye fed.
[10] U. S. supply of byproduct feeds. Regression coefficient is statistically nonsignificant.

An analysis of the demand for all food represents too high a degree of aggregation for most purposes. Livestock products account for more than 60 percent of the retail value of food products sold to domestic consumers and originating on farms in the United States. Consumer purchases of livestock products respond significantly to changes in price. Demand elasticities for several of these products range from —0.5 to —1.0.

The foods mainly of plant origin include some fruits and vegetables for which demand is even more elastic than the demand for meat. They also include potatoes, dry beans, cereals, sugar, and fats and oils, for which both price and income elasticities of consumption are extremely small.

Aggregative analyses of the demand for all food yield regression coefficients which are weighted averages of these diverse elasticities for individual foods. If the price of every food at retail dropped 10 percent (income remaining constant in real terms) total food consumption might increase by something like 3 to 4 percent. However, the consumption response is not independent of the distribution of price changes for individual foods if we relax the assumption of parallel price movement. A drastic decline in prices of potatoes, flour, sugar, and lard would have a negligible effect on total food consumption if prices of meats, poultry, fruits and vegetables, remained constant. On the other hand, a 10-percent drop in an index of food prices caused by a 30-percent drop in the price of meat might well lead to a 6-percent increase in an index of total food consumption.

FEED CROPS.—Table 8 summarizes some price-estimating equations for hay and corn. The U. S. average farm price of hay generally dropped about 1.4 percent in response to 1-percent increase in total supply of hay. The demand factor used in the hay analysis is an index of cash receipts from sales of dairy products and beef cattle, weighted in pro-

portion to total hay consumption by dairy and beef cattle respectively. The price of hay changed somewhat less than proportionately to this demand index.

The first analysis shown for corn expresses corn prices as a function of total supplies of corn, oats, barley, and grain sorghums. These grains are closely substitutable for corn in most feeding uses. A 1-percent increase in total supplies of the four grains generally reduced the price of corn almost 2 percent.

Two demand factors are used in this analysis. The first is an index of prices received by farmers for livestock products, with each product weighted approximately by its grain requirements. The regression coefficient indicates that a 1-percent increase in the average price of grain-consuming livestock is associated with very nearly a 1-percent increase in the price of corn. This is consistent with the function of livestock-feed price ratios as equilibrating mechanisms for the feed-livestock economy. The second demand factor in this equation is the number of grain-consuming animal units on farms as of January 1. This coefficient is significant but is not so accurately established as the other coefficients in the equation. It implies that a 1-percent increase in grain-consuming animal units from one year to the next tends to increase corn prices by perhaps 2 percent.

The other two analyses for corn illustrate points that are sometimes overlooked in price analysis. As other feed grains are substitutable for corn the net effect of a 1-percent increase in corn supplies upon corn prices (supplies of other feeds remaining constant) is less than the effect obtained if supplies of all feed grains increase by 1 percent. The last analysis subdivides the total supply of feed concentrates into three parts. During 1922-41 the net response of corn price to corn supply was not much more than —1.2. The response of corn prices to changes in supplies of other feed grains was approximately —.8. The regression of corn prices upon supplies of byproduct feeds was positive but statistically nonsignificant. The positive sign is not wholly implausible since these feeds are used to a large extent as supplements rather than substitutes for corn.

Table 8 also summarizes some simple regression relationships between year-to-year changes in prices of other feeds and the price of corn. The level of correlation obtained is a rough indicator of the closeness of competition between the other feeds and corn on a short-run (year-to-year) basis.

Export Crops.—All of the analyses referred to in tables 3 through 8 are based on the traditional single-equation approach. This approach is not conceptually adequate to derive the complete demand structures for export crops such as wheat, cotton, and tobacco. In the absence of price supports, at least two (relatively) independent demand curves are involved in determining their prices—domestic and foreign.

It is possible, however, to get approximate estimates of the response of domestic consumption of wheat and cotton (and possibly tobacco) to changes in their farm prices. An exploratory analysis by the author yielded a demand elasticity (with respect to farm price) of —.07 (± .027) for the domestic food use of wheat. Other investigators have obtained elasticities of about —.2 (with respect to spot market prices) for the domestic mill consumption of cotton. The domestic consumption of tobacco products also appears to respond very little to changes in the farm price of tobacco.

Comparison of Time-Series Results with Family-Budget Studies

The problem of reconciling time-series and family-budget data on demand has interested economists for many years. Among other difficulties, few analysts have found sufficiently good data of both types to work with. These pages are exploratory, but they may stimulate some fruitful discussion and criticism. Space does not permit a full exposition of the methods used in this section, but a brief indication is given in table 9, footnote 1.

Table 6 contains two time-series analyses that were designed to simulate as nearly as possible the conditions prevailing in family-budget studies. One coefficient in each equation measures the relationship between consumption and real disposable income with prices of all commodities held constant by statistical means. These coefficients are compared in table 9 with corresponding family-budget regressions based on data collected by the Bureau of Human Nutrition and Home Economics in the spring of 1948. (See also table 10.)

Consumption in the time-series equation for food livestock products is measured by means of an index number. A pound of steak is weighted more heavily than a pound of hamburger and, of course, much more heavily than a pound of fluid milk. The

TABLE 9.—*Relationships between consumption and income as measured from time series and from family budget data, United States, 1922-41 and 1948*

Item	Net effect of 1-percent change in per capita income upon:		
	Consumption per capita (time series data, 1922-41)	Expenditure per capita [1] (family budget data, spring 1948)	Quantity purchased per capita [1] (family budget data, spring 1948)
	Percent	*Percent*	*Percent*
All food livestock products	0.40 [2] (.03)	0.33	0.23
All meat	.51 [2] (.05)	[3] .36	.23

[1] See table 10, footnote 2. A fuller statement of the methods used to obtain these coefficients will be supplied on request.

[2] Standard error of time series coefficient. Comparable measures for the family budget coefficients are not available, as the coefficients were calculated from grouped data.

[3] Meat, poultry, and fish. Coefficient for meat alone would be slightly higher.

weights are average retail prices in 1935-39. Hence the time-series regression implies that if all prices are held constant, *expenditures* will increase with income in the proportions indicated.

Conversely, the expenditures shown in family-budget data are analogous to price-weighted indexes. As the price of each type, cut, and grade of product is the same to consumers of all income groups during the week of the survey, expenditures for livestock products at two family-income levels are equal to the different quantities bought, multiplied by the same fixed prices.

Consumption in the time-series analysis for meat is measured in pounds (carcass-weight equivalent) but each "pound" is a composite of all species, grades, and cuts. Expenditures at constant prices will change almost exactly in proportion to these "statistical pounds." But the actual pounds shown in family-budget data reflect more expensive cuts and grades at high- than at low-income levels. In the 1948 study, average prices per pound paid by the highest income group exceeded those paid by the lowest in the following ratios: All beef, 34 percent; all pork, 28 percent; all meat, 35 percent; meat, poultry, and fish combined, 32 percent. On the average, a pound of meat (retail weight) bought by a high-income family represented a greater demand upon agricultural resources than a pound of meat bought by a low-income family.

There are strong arguments for comparing the expenditure-income regressions from family-budget data with the consumption-income regressions from time series. The coefficients are not unduly far apart, considering the possible factors that make for differences. Among other things, 1948 was a year of full employment. As the income elasticity of food consumption decreases at higher family-income levels, and as the family-budget observations have been weighted according to the high-income pattern of 1948, the regression coefficients in table 10 are probably lower than would have been obtained on the average during 1922-41.

Some internal features of the family-budget data for 1948 deserve comment. In the case of livestock products the expenditure coefficients more nearly reflect demands upon agriculture (hence, real income to agriculture) than do the quantity coefficients. The differences between the two sets of coefficients are largely due to differences in type and quality of products consumed, with the significant aspects of quality being reflected back to farmers in the form of higher farm values per retail pound.

The situation with respect to two of the fruit and vegetable categories seems to be similar to that of livestock products (table 10). The difference between expenditure and quantity coefficients probably reflects increasing use of the more expensive types and qualities within each commodity group. The higher income families may be paying more for marketing services, but they are also paying more per pound to the farmer.

This is only partly true in the "other foods" group. *Grains* at the farm level are fairly homogenous. The difference between expenditure and quantity regressions for grain products must largely reflect differences in marketing services (baked goods versus flour, and so forth). *Sugars* and *sweets* include candy, soft drinks, and preserves, and sugars and sirups. To the extent that candy includes domestically produced nuts, or that preserves include domestic fruits and berries, the positive expenditure coefficient indicates some benefits to farmers. But most of the difference between expenditure and quantity regressions for sweets goes to bottlers, confectioners, and distributors.

The positive expenditure coefficient for *fats* and *oils* is mainly due to the greater use of butter by the higher income groups. Because of this fact, the expenditure coefficient more nearly represents the demand for agricultural resources in the produc-

TABLE 10.—*Food expenditures and quantities purchased: Average percentage relationship to family income, urban families, United States, spring 1948*

Item	Relative importance[1] (1)	Effect of one-percent change in income upon:		
		Expenditure (2)	Quantity purchased (3)	Col. (2) minus Col. (3) (4)
		Percent[2]	*Percent*[2]	*Percent*[2]
A. Per family:				
All food expenditures		*0.51*		
At home		.40		
Away from home		1.12		
B. Per family member:[3]				
All food expenditures		*.42*		
At home		.29		
Away from home		1.14		
C. Per 21 meals at home:[3]				
All food (excluding accessories)	*100.0*	*.28*	[4]*0.14*	*0.14*
All livestock products	*50.8*	*.33*	[4] *.23*	*.10*
Meat, poultry and fish	29.2	.36	.23	.13
Dairy products (excluding butter)	16.9	.32	.23	.09
Eggs	4.7	.22	.20	.02
Fruits and vegetables	*19.0*	*.42*	[4] *.33*	*.09*
Leafy, green and yellow vegetables	4.9	.37	.21	.16
Citrus fruit and tomatoes	5.2	.41	.42	— .01
Other vegetables and fruits	8.9	.45	.35	.10
Other foods	*30.2*	*.08*	[4]— *.12*	*.20*
Grain products	11.4	.02	— .21	.23
Fats and oils	9.8	.13	— .04	.17
Sugars and sweets	5.2	.20	— .07	.27
Dry beans, peas and nuts	1.5	— .07	— .33	.26
Potatoes and sweetpotatoes	2.3	.05	— .05	.10

[1] Percent of total expenditures for food used at home, excluding condiments, coffee, and alcoholic beverages.

[2] Regression coefficients based upon logarithms of food expenditures or quantities purchased per 21 meals at home and logarithms of estimated Spring 1948 disposable incomes per family member, weighted by proportion of total families falling in each family income group. The object was to obtain coefficients reasonably comparable with those derived from time series.

[3] Per capita regression coefficients are lower than per family coefficients in this study whenever the latter are less than 1.0. This happens because average family size was positively correlated with family income among the survey group. A technical demonstration of this point will be supplied on request.

[4] Weighted averages of quantity-income coefficients for subgroups.

Basic data from UNITED STATES BUREAU OF HUMAN NUTRITION AND HOME ECONOMICS. 1948 FOOD CONSUMPTION SURVEYS. PRELIMINARY REPT. No. 5, May 30, 1949; tables 1 and 3.

tion of fats and oils. In the group comprising dry beans, peas, and nuts, the first two decline rapidly and the third increases rapidly as family income rises, so the expenditure regression is more relevant to farm income than is the quantity coefficient.

For all foods (excluding condiments, alcoholic beverages, and coffee) the 1948 survey of BHNHE indicates a tendency for expenditures per 21 meals at home to rise about 28 percent as much as family income per member. The weighted average of the quantity-income regressions is about 14 percent. One-fourth, or one-third, of the difference probably goes to marketing services. On balance, it appears that, in 1948, a 10-percent difference in income per family member meant a difference of roughly 2.5 percent in the per capita demand for agricultural resources used in food production.

This effect was a weighted average of 3.3 percent for livestock products, 4.2 percent for fruits and vegetables other than potatoes, and *slightly less than zero* for other foods as a group. These coefficients indicate the direction in which consumers tend to adjust their food patterns as their incomes increase. At present, per capita consumption of grain products and potatoes is 15 percent lower than in 1935-39. The demand for spreads for bread has also been caught in this downtrend, so that the per capita consumption of butter and oleomargarine combined in 1950 was 3 pounds, or 15 percent, below the prewar average. Consumption of sugar and total food fats and oils per person

was about the same in 1950 as in 1935-39. On the other hand, per capita consumption of livestock products (excluding butter and lard) was up more than 23 percent and consumption of fruits and vegetables (aside from potatoes and sweetpotatoes) was up 9 percent.

Two other points might be noted in closing: (1) The regression of *calories* upon income per family member is somewhat less than the average quantity gradient of 14 percent would suggest, as costs per calorie are considerably lower for sugar, fats and oils, and grain products, than for livestock products and fruits and vegetables; (2) the demand for *restaurant meals* seems to increase slightly more than 10 percent in response to a 10-percent increase in income per family member. This implies, of course, a similar increase in demand for restaurant services.

A Study of Recent Relationships Between Income and Food Expenditures

By Marguerite C. Burk

Postwar variations from prewar levels in income, expenditures, and prices have necessitated the reconsideration and re-evaluation of our ideas of consumer demand for food. The Bureau of Agricultural Economics has been devoting attention to the improvement of food consumption data and analyses, particularly those which are useful in forecasting demand in terms of quantities and prices. This article, prepared under the Agricultural Research and Marketing Act of 1946, analyzes relationships between food expenditures and income, including an appraisal of the static and dynamic forces involved.

AT FIRST GLANCE, data on food expenditures and income in the United States in the past 20 years indicate that a larger proportion of income has been spent for food in this postwar period of record high incomes than in less prosperous years. This is contrary to what one would expect on the basis of Engel's famous law and the results of many studies of family expenditures. Engel's law is generally remembered as stating that families with higher incomes spend a smaller proportion of their incomes for such necessities as food than do families with smaller incomes. If that is true of individual families, should it not hold for national averages? But can Engel's law be applied to historical comparisons of national averages? If it can be, what is the explanation of the apparent contradiction in the postwar period?

The analysis of the problem posed by these questions will proceed in five steps. First, we shall point out the principal differences between the static and dynamic aspects of the problem of income-food expenditure relationships. Second, we shall review information on family food expenditures and income taken from sample surveys, often called family-budget data. These are similar to the data collected by Engel, and each survey reflects an essentially static situation. Third, a set of data on food expenditures and income will be developed under partly static and partly dynamic concepts; that is, including changes in the food consumption pattern and income through time, but excluding changes in the price level, in relative prices, and excluding major shifts in marketing. Fourth, we shall arrive at a fully dynamic situation by adding price changes to the set of data developed in the preceding section, then by making certain adjustments in the Department of Commerce food expenditure series and in the Department of Agriculture series on the retail cost of farm food products, and then comparing the results with disposable income per capita. The pattern of these comparisons will be examined to learn whether, through time, there is a strong tendency of income-food expenditure relationships to adhere to the static pattern, that is, to follow Engel's law. Finally, the postwar situation will be analyzed to ascertain the extent to which the variation of income-food expenditure relationships in 1947-50 from the prewar pattern reflects either temporary aberrations in the underlying pattern, or an enduring shift in relationships which may or may not still evidence the pattern predicated by Engel's law.

Obviously, the average proportion of income spent for food in the entire country is a weighted average of the income-expenditure relationships of all families and individuals, from the lowest to the highest incomes. But the comparison of the average proportion of income spent for food in the United States over several years involves a shift from a static to a dynamic concept and introduces a new complex of factors.

Let us begin by recalling the circumstances under which Engel developed his law. Ernst Engel studied the expenditures of families of all levels of income in Belgium and Saxony, in the middle of the nineteenth century. His data showed a consistently higher percentage of total expenditures going for food coincident with lower average incomes per family. He concluded, "The poorer a family, the greater the proportion of the total out-

go that must be used for food."[1] It is to be noted that Engel's analysis was confined to one period in time. The data on food expenditures which he examined included costs of alcoholic beverages, and the food purchases were almost entirely for home consumption. Furthermore, food commodities in that century were not the heterogeneous commodities they are today. Families bought raw food from rather simple shops or local producers and did most of the processing at home. Their food expenditures did not include such costs as labor and cooking facilities in the homes. Now, families have a wide choice of kinds of places to buy their food, of many more foods both in and out of season, of foods extensively processed into ready-to-serve dishes, and of eating in many kinds of restaurants. Accordingly, families of higher income now may spend as large a proportion of their incomes as lower income families, or even a larger proportion, by buying food of better quality, expensively processed, and with many marketing services.

Such developments in food commodities and marketing might be expected to affect income-food expenditure relationships over time in the same way as at a particular period. Numerous other factors are present in the dynamic situation which do not enter into the problem at a given period and given place, although they are significant in place-to-place comparisons, which are considered only incidentally in this study. These dynamic factors include changes in the average level of income, distribution of income, the geographic location and the composition of the population, relative supplies of food and nonfood commodities, and changes in both the general price level and relative prices, and also changes in the manner of living that are independent of income. With these factors in mind, we shall examine income-food expenditure relationships of aggregate data for a 20-year period to learn whether there is a pattern and to what extent economic and social disturbances have caused variations from that pattern.

Survey Data on Income-Food Expenditure Relationships

Data on food expenditures and incomes in this country are of two types: (1) information on family-food expenditures taken from sample surveys, often called family-budget data, similar to those collected by Engel and essentially static in character and (2) aggregate time-series data such as those of the Department of Commerce and the Department of Agriculture. The survey data here used were obtained from reports by individuals and families, as those of the *1935-36 Consumer Purchases Study*, the *1941 Study of Spending and Saving in Wartime,* and the *1948 Food Consumption Surveys* (urban). These data must be handled cautiously and they require many adjustments before they can be compared.[2]

For purposes of analysis, approximations can be made to meet most of the problems inherent in the data except that of consistent under-reporting of expenditures for snacks and meals away from home and for beverages. However, value of food consumed at home appears to be somewhat high in the aggregate and presumably offsets this underreporting to a considerable but unknown extent.[3] As the underreporting of such expenditures is likely to be greater in the higher income groups than in the lower, the income-elasticity of demand derived from reported data is probably understated.

Table 1 contains the data on food and beverage expenditures for the whole population derived by the author from the 1935-36 and 1941 surveys, as well as roughly comparable data on total consumer disposable income per person, the proportion thereof being used for such expenditures, and average food and beverage expenditures per person. Several observations are in order at this point. Comparison of the percentages spent for food in the two studies can be made, although there was a

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[1]Translated from page 26—DIE LEBENSKOSTEN BELGISCHER ARBEITER-FAMILIEN FRÜHER UND JETZT—ERMITTELT AUS FAMILIEN-HAUSHALTSRECHNUNGEN. Inst. Internatl. Statis. Bul. 9: 1-124. illus. 1895.

[2] Numerous references to their limitations can be found in the literature. One of the best articles is by DOROTHY S. BRADY and FAITH M. WILLIAMS. ADVANCES IN THE TECHNIQUES OF MEASURING AND ESTIMATING CONSUMER EXPENDITURES. Jour. Farm Econ. Vol. 27:2:315-44. May 1945. Others are the papers by SELMA GOLDSMITH in Volume 13 of the STUDIES IN INCOME AND WEALTH, issued by the NATIONAL BUREAU OF ECONOMIC RESEARCH, and by STANLEY LEBERGOTT before the American Statistical Association, 1949, unpublished, and Part II, FAMILY SPENDING AND SAVING IN WARTIME, Bulletin No. 822, UNITED STATES DEPARTMENT OF LABOR, BUREAU OF LABOR STATISTICS, 1945.

[3] For example, expenditures for alcoholic beverages reported in the 1941 study averaged only a little over $7 per person, whereas the Department of Commerce estimate of such expenditures in 1941 is about $32 per capita. Data from the same survey on expenditures for food away from home yield an average of $22 per person, but an estimate derived from Commerce data for the same year totals $30. On the other hand, food consumed at home, including home-produced foods, was valued at $156 per person. After making adjustments in Commerce data to bring them to the same price level, the average was only $133 per capita.

TABLE 1.—*Average disposable income and food expenditure per capita, and proportion of income spent for food, by income group, 1935-36 and 1941*[1]

Total income per consumer unit[2]	Average disposable income per capita in current dollars	Food expenditures per capita: Average in current dollars	Food expenditures per capita: Percentage of disposable income
	Dollars	*Dollars*	*Percent*
		1935-36	
Under $500	113	69	61
$500 to 999	242	104	43
1,000 to 1,499	370	132	36
1,500 to 1,999	502	154	31
2,000 to 2,999	679	179	26
3,000 to 4,999	982	209	21
5,000 and over	3,270	344	11
Average	462	134	29
		1941	
Under $500	122	91	75
$500 to 999	293	130	44
1,000 to 1,499	446	167	37
1,500 to 1,999	529	179	34
2,000 to 2,999	734	206	28
3,000 to 4,999	1,008	247	24
5,000 and over	2,027	354	18
Average	680	191	28

[1] Data derived by author from 1935-36 CONSUMER INCOME AND EXPENDITURE STUDIES of the NATIONAL RESOURCES COMMITTEE and 1941 STUDY OF SPENDING AND SAVING IN WARTIME. Disposable income includes money and nonmoney incomes; 1941 incomes adjusted for underreporting. Food expenditures include expenditures for alcoholic beverages and for food away from home, and home-produced food valued at local prices. All data exclude residents of institutions.

[2] Approximates disposable income.

small difference in the price level between the two surveys and some redistribution of incomes in the two open-end groups. There seems to have been remarkable stability in the relationships of all but the highest and lowest income groups. The income elasticities of the two sets of data are fairly similar.[4] Engel's law is certainly borne out in each of

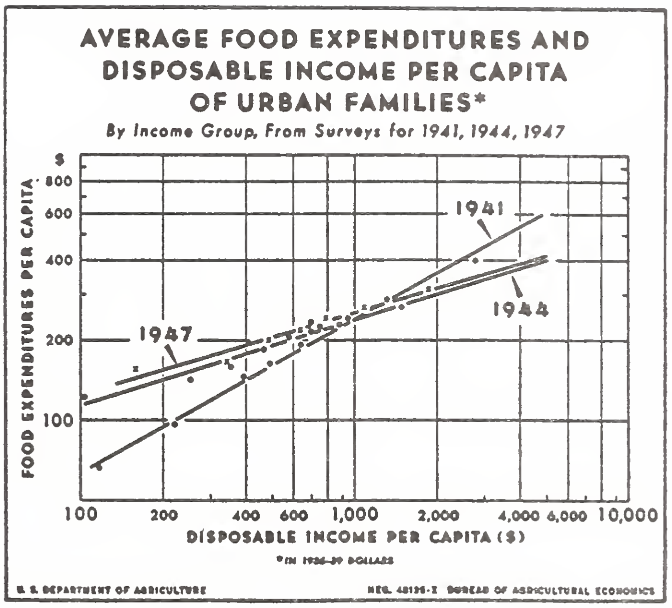

FIGURE 1.

these sets of data. The single-point difference between the average proportions of income spent for food in 1935-36 and 1941 precludes using these data for argument for or against the application of Engel's law through time.

The income elasticities derived from the 1941 data on urban families' incomes and food expenditures and from comparable 1947 data reported in the 1948 spring survey, are significantly different —0.58 for the former and 0.31 for the latter. As a check, a similar analysis of the study for 1944 by the Bureau of Labor Statistics[5] was made, yielding a 0.33. The data from these studies have been plotted on figure 1 in terms of constant 1935-39 dollars. The differences in the slopes of the three lines, which were fitted by least squares, indicate the differences in average income elasticity of food expenditures. Analysis of the possible causes for such differences will follow in the last section of this article.

Static-Dynamic Situation

Although Engel's law of food expenditures is directly applicable only to the static situation described above, it seems logical that it should be reflected to some extent in a dynamic economy by time-series data on national income and food expenditures. We investigate this possibility by constructing a time series to match most of the basic concepts of the family-budget data.

[4] The regression lines fitted to the logarithms of average expenditures per person, for food and alcoholic beverages, money and non-money, against logarithms of average total disposable income per person, all in current dollars, are for 1935-36, $Y' = .88 + .48X$, and for 1941, $Y' = .93 + .49X$. Both $R^2 = .99$. Regression lines fitted in a comparable way to data for urban families in 1941, 1944 and 1947 gave the following equations: 1941, $Y' = .64 + .58X$, $R^2 = .99$; 1944, $Y' = 1.47 + .33X$, $R^2 = .95$; 1947, $Y' = 1.61 + .31X$, $R^2 = .96$, based on unpublished data of the Bureau of Human Nutrition and Home Economics. The coefficients of X in these equations are a measure of the income-elasticity of demand for food at a particular period, that is, "static income-elasticity."

For discussion of the technical problems of measurement, see LEWIS, H. GREGG, and DOUGLAS, PAUL H. STUDIES IN CONSUMER EXPENDITURES. The University of Chicago Press, Chicago, Ill. 1947. Also, ALLEN, R. G. D., and BOWLEY, A. L. FAMILY EXPENDITURES, Staples Press Limited. London, 1935.

[5] From table 2, EXPENDITURES AND SAVINGS OF CITY FAMILIES IN 1944, Monthly Labor Review, January 1946.

TABLE 2. — *Estimated retail value of foods consumed per civilian, including expenditures in public eating places, in 1935-39 and current dollars, and ratios to real and current disposable income, 1929-50*

Year	Estimated retail value of food in			
	1935-39 dollars		Current dollars	
	Average per civilian[1]	As a percentage of real disposable income per capita[2]	Average per civilian[3]	As a percentage of current disposable income per capita
	Dollars	*Percent*	*Dollars*	*Percent*
1929	145	26.5	193	28.6
1930	144	28.9	181	30.4
1931	143	30.7	148	29.4
1932	139	35.5	120	31.5
1933	137	35.5	115	32.2
1934	138	32.7	130	32.0
1935	135	29.3	136	30.0
1936	141	27.1	142	27.8
1937	142	26.6	150	27.3
1938	143	26.8	140	27.9
1939	148	27.6	141	26.4
1940	151	26.6	146	25.6
1941	157	24.0	165	24.1
1942	158	21.4	196	22.7
1943	161	20.6	222	23.0
1944	166	19.7	226	21.3
1945	172	20.5	239	22.2
1946	177	22.1	283	25.3
1947	171	23.2	331	28.3
1948	165	22.2	348	27.2
1949	164	22.2	331	26.5
1950[4]	165	21.2	336	25.3

[1] Value aggregates of civilian per capita food consumption index plus estimated extra cost of food in public eating places, in constant 1935-39 dollars.

[2] Department of Commerce series on disposable income deflated by consumers' price index.

[3] Value in 1935-39 dollars multiplied by BLS retail food price index.

[4] Preliminary.

The construction proceeded as follows: The basis for the series was the value aggregates of the civilian per capita food consumption index (quantities of major foods consumed per person multiplied by average retail prices in 1935-39). To these were added estimates of the extra cost for services of public eating places on a per capita basis, estimated from Department of Commerce food-expenditure data, and deflated by the consumers' price index in order to approximate constant prices. The total estimated retail cost of food per person plus additional costs of food served in public eating places was then compared with real disposable income per capita (table 2).

This derived series has the character that would be expected on the basis of Engel's law—we find a higher proportion of income going for food purchases in depression years and a smaller proportion in prosperous years. It represents a static situation in that it does not reflect price changes through time, nor changes in marketing channels. Moreover, because of the rather simple structure of prices used, it does not reflect some of the additional expenditures for commercial processing. On the other hand, some dynamic factors are reflected in the series because they have brought about changes in the rates of food consumption through time. Among these are changes in average incomes and distribution of incomes among consumer units and changes in relative supplies of food and nonfood goods and services. The series explicitly includes the increased expenditures for eating away from home.

Dynamic Situation

The next step toward a dynamic situation is relatively simple. It is the introduction of price changes. The per capita food-value series in constant 1935-39 dollars was multiplied by the retail food price index (1935-39 = 100) and the resulting series was compared with disposable income in current dollars. For prewar years the income-food expenditure relationships changed from year to year in about the way that would be expected from Engel's law. The data for the war years reflect, of course, the controlled prices. For the years after the decontrol of prices in 1946, the introduction of the price factor puts the income-food expenditure relationships out of line with the pattern of the years before 1942. These data present us with the core of our problem, but we defer its analysis until the next section.

At this point, it is necessary to indicate certain deficiencies, from a dynamic standpoint, still inherent in this derived series on retail value of food consumed. They stem from the basic concept of the per capita food consumption index which was constructed to measure quantitative changes in food consumption, rather than qualitative changes or changes in food expenditure.[6] This index includes shifts in consumer purchases from fresh to processed fruits, vegetables, fish and dairy products; but it excludes such shifts within the meat, sugar, and flour categories, as well as the consumption of offals (which is assumed to vary directly

[6] For description of the index, See UNITED STATES BUREAU OF AGRICULTURAL ECONOMICS, CONSUMPTION OF FOOD IN THE UNITED STATES, 1909-48. U. S. Dept. of Agr. Misc. Pub. 691, June 1949, pp. 88-96.

TABLE 3.—*Department of Commerce estimates of food expenditures, including alcoholic beverages, and adjusted estimates of food expenditures, per person and as a percentage of disposable income, 1929-50*[1]

Year	Food and alcoholic beverage expenditures		Expenditures for food including rough adjustments to exclude military food and value all food except that in public eating places at retail	
	Per person in current dollars	As percentage of disposable income	Per person in current dollars	As percentage of disposable income
	Dollars	*Percent*	*Dollars*	*Percent*
1929	160	23.8	179	26.6
1930	146	24.5	164	27.6
1931	118	23.4	136	26.9
1932	91	23.9	107	28.0
1933	91	25.4	102	28.5
1934	112	27.6	112	27.6
1935	127	28.0	123	27.1
1936	143	27.9	134	26.1
1937	154	28.1	142	25.9
1938	145	28.9	135	26.9
1939	146	27.4	134	25.2
1940	156	27.4	141	24.8
1941	182	26.5	163	23.8
1942	228	26.4	201	23.3
1943	257	26.6	232	24.0
1944	280	26.5	247	23.3
1945	306	28.4	268	24.9
1946	354	31.7	310	27.7
1947	391	33.4	349	29.9
1948	406	31.8	371	29.0
1949	390	31.2	356	28.5
1950[2]	396	29.8	362	27.2

[1] See text for description of adjustments.
[2] Rough estimates only.

with consumption of carcass meat, but contributes an increase of $3). The inclusion of these factors would add about $5 to the average retail value of food consumed in 1939 and $15 in 1947 (in current dollars).

The effect of two other factors in food expenditures, which were important only in the war period of the two decades covered by the data, is also omitted by this series. The factors are the understatement of prices by the retail-price series during the war (because of such developments as disappearance of low-cost items and deterioration of quality) and shifts from lower cost to higher cost marketing channels — for example, from chain stores to small independent stores. The shifts are discussed later.

We are now ready to analyze two well-known series relating to food expenditures—the Department of Commerce series on food expenditures and the Department of Agriculture series on the retail cost of farm food products. Although both of these are affected by dynamic factors, certain adjustments are necessary to bring them in line with the concepts of retail value of the survey data on food expenditures. The Commerce series is compiled as part of the process of estimating national income.[7] It should be noted that these data include food and beverages purchased for off-premise consumption (valued at retail prices), purchased meals and beverages (including service, etc., valued at prices paid in public eating places), food furnished to commercial and Government employees including military (valued at wholesale), and food consumed on farms where grown (valued at farm prices).

The following very rough adjustments were made in the Commerce series: (1) A rough division of expenditures for alcoholic beverages was made into purchases for off-premise consumption and purchases with meals; the former was then subtracted from the combined total of off-premise food and alcoholic beverages expenditures. (2) Food furnished civilian employees was revalued at approximately the retail level as was food consumed on farms where produced. (3) The revised estimate of total retail value of civilian food (in current dollars) was put on a per capita basis and compared with disposable income per capita. This series (table 3) bears out Engel's law until about 1945. From then on, the proportions of disposable income spent for food are even more out of line with prewar years than are those in the new series described above.

The other existing series, the retail cost of farm food products,[8] excludes food consumed on farms where produced, imported foods, non-civilian takings, nonfarm commodities, and alcoholic beverages. To obtain comparability, estimates of the retail value of farm-produced and farm-home-consumed foods, of the nonfood costs in public eating places, of the retail value of imported foods, and of fish and fishery products, were added to the retail cost of farm food products. Table 4 contains the adjusted series and comparisons with disposable income.

Comparison of the three series indicates that the general patterns are rather similar although the levels are somewhat different. The series derived from the value aggregates of per capita consumption is generally lower than the adjusted series

[7] For a brief summary of the methods used in constructing this series, see *ibid.*, pp. 96-98.
[8] *Ibid.*, pp. 98-100, and The Marketing and Transportation Situation, September 1950, pp. 11-15.

TABLE 4.—*Retail cost of farm food plus adjustments to cover all foods and extra services of public eating places, total and per capita compared with disposable income, 1929-50*

Year	Retail cost of farm food[1]	Adjusted retail cost of all foods for civilians[2]		Adjusted retail cost per capita as percentage of disposable income
		Total	Per capita	
	Million dollars	*Million dollars*	*Dollars*	*Percent*
1929	17,920	24,900	203	30.2
1930	16,810	23,420	189	31.8
1931	13,600	19,200	154	30.5
1932	11,070	15,770	126	33.0
1933	11,340	15,770	125	34.9
1934	12,870	17,570	138	34.1
1935	13,470	18,780	147	32.4
1936	14,720	20,200	157	30.5
1937	14,690	20,390	157	28.7
1938	13,960	19,340	148	29.5
1939	14,100	19,340	147	27.5
1940	14,630	19,870	150	26.2
1941	16,530	22,410	169	24.6
1942	19,900	26,430	200	23.2
1943	22,110	29,960	231	24.0
1944	22,060	30,250	234	22.1
1945	23,630	32,330	249	23.1
1946	30,450	40,610	292	26.1
1947	35,950	47,830	333	28.5
1948	37,970	50,310	344	26.9
1949	36,200	47,690	321	25.7
1950[3]	36,800	48,500	321	24.3

[1]From table 5, p. 12, *Marketing and Transportation Situation*, September 1950.
[2]Adjusted as described in text.
[3]Rough estimates only.

based on retail cost of farm food products. On the other hand, the series derived from the Department of Commerce food-expenditure data is significantly lower in prewar years and higher since 1943 than the data in the other two series.

Study of the proportion of average disposable income spent for food in relation to the level of real income in the years 1929-41, as measured by each of the series (fig. 2), leads to the surmise that national averages of income-food expenditure relationships through time do tend to follow Engel's law.[9] The complexity of wartime price and supply relationships prevents our drawing any conclusion from the lower percentages spent for food during the years 1942-45, when real income per capita was the highest on record. The ratios of average food expenditures to average disposable income since 1945 bring us to our real problem.

Postwar Income-Food Expenditure Relationships

A higher ratio of food expenditures to disposable income, in terms of national averages, can result from (1) lower average real incomes, which would be accompanied by a change in the proportional distribution of the population among and/or within the several real-income groups; (2) an increase in average food expenditures, with or without a change in the "static income-elasticity of demand." An example of this would be a rise in the average food expenditures of two or three adjacent income groups with none in the others and no change in average incomes of each group. If there is an equi-proportional rise in food expenditures of all income groups, there will be no change in static income-elasticity of demand but a higher "dynamic income-elasticity of demand" would result. This term is used here to describe the relationship of changes through time in the national average of food expenditures to changes in national average income.[10]

The situation in 1946-49 did not result from the first of these alternatives because real incomes per person (disposable) were substantially higher than before the war, although they were somewhat less than in 1945.

The fact that food expenditures have increased more than incomes since 1940 and 1941, so that the ratio between the two has risen, indicates an increase in the demand for food. Is this increase likely to be permanent or have unusual factors of short duration brought about only temporary aberrations in the underlying pattern of income-food expenditure relationships? Obtaining an answer to this question necessitates the determination of the

[9]The following regression equations were calculated from the logarithms of the income-food expenditure ratios (Y) and of the index of real disposable income per capita (X) (1935-39 = 100), fitted 1929-41;
(a) Series derived from per capita consumption and retail food price indexes
$Y' = 2.54 - .55X$; $R^2 = .86$
(b) Adjusted Commerce food expenditure series
$Y' = 2.04 - .31X$; $R^2 = .83$
(c) Series based on retail cost of farm food products
$Y' = 2.71 - .62X$; $R^2 = .83$

[10]The regression equations for the logarithms of the four food expenditures series (Y) and the logarithms of disposable income per capita (X), 1929-41 are:
(a) Series derived from per capita consumption data, in constant dollars (against real disposable income)
$Y' = 1.53 + .23X$, $R^2 = .73$
(b) Series derived from per capita consumption and retail food price indexes (current dollars)
$Y' = .35 + .67X$; $R^2 = .84$
(c) Adjusted Commerce food expenditure series (current dollars)
$Y' = -.07 + .81X$; $R^2 = .96$
(d) Series based on retail cost of farm food products (current dollars)
$Y' = .53 + .61X$; $R^2 = .78$

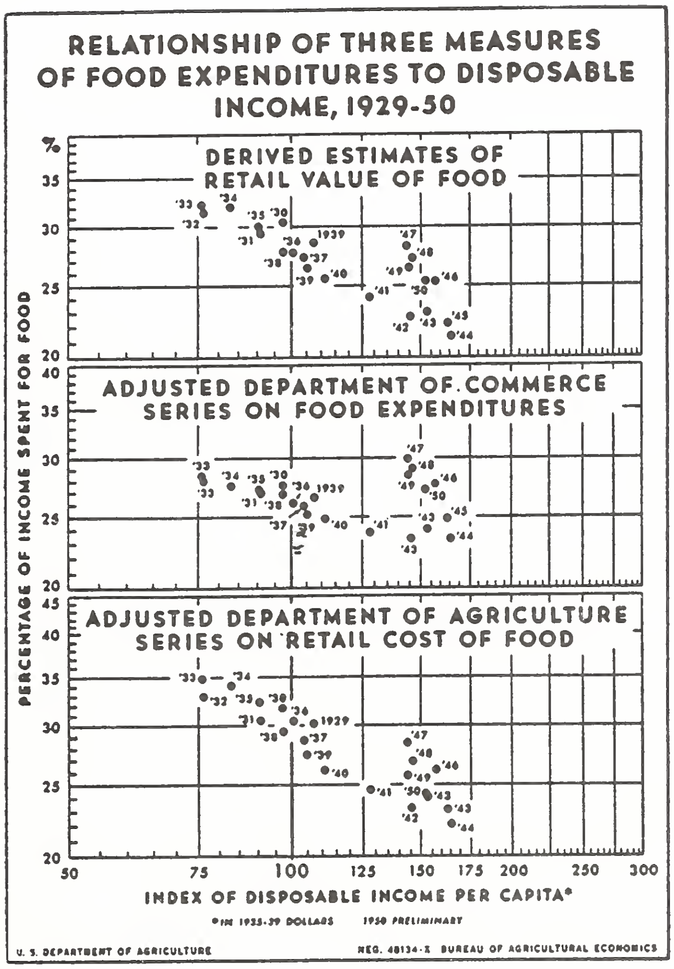

FIGURE 2

major factors in higher food expenditures and insofar as possible the evaluation of their importance. A supplemental problem is the determination of whether the change in demand for food has taken place equally at all income levels or only in some segments; that is, whether the "static income-elasticity of demand for food" has changed.

The first step in the analysis of postwar income-food expenditure relationships is to measure so far as possible the effect of changes in the average level of income and the distribution of income within the population on the national average of the relationship of food expenditures to income. The sum of the population in each income group multiplied by the average income of that group divided by the total population, will give a reasonable approximation of average income. A similar procedure will give average food expenditures. In order to evaluate the effect of changing income on income-food expenditure relationships, it is advantageous to hold prices constant. Distributions of individuals by total disposable real income per consumer unit have been developed for several years (adjusted to consumers' price index of 133), although they should be regarded only as rough approximations. These were used to derive weighted averages of income and food expenditures (including alcoholic beverages) for those years. The weighted averages of income in 1943 and 1946 underestimate the average income in those years by 5 to 10 percent, according to comparable estimates of non-military, non-institutional income derived from data of the Department of Commerce. This is largely the result of some upward shift within income groups, particularly that with real incomes above $5,000. However, an accompanying upward movement in the averages of food expenditures for each group would be expected.

In table 5 the derived estimates of income and food expenditures, adjusted to exclude the costs of alcoholic beverages, are compared. The results indicate that food expenditures would have been expected to take 31 percent of total disposable income in 1935-36 and 24 percent in 1948 if people at each level of real income in those years spent the same proportion of income for food as did people at that income level in 1941. In other words, all factors except income are held constant and there is no change in static income-elasticity of demand for food. Under these conditions, the national averages of the relationship of food expenditures to income would follow Engel's law. With about the same real disposable income in 1949 as in 1948 we might expect the same proportion of income to have been spent for food.

At this point, we recall that the static pattern of income-food expenditure relationships did change for urban families between 1941 and 1947, as shown by figure 1. This change indicates the importance of factors other than shifts in the distribution of income and higher average income to the level of postwar food expenditures. These factors may be short or long in duration.

Two obviously short-run factors were (1) the natural lag in adjustment of food-consumption patterns to rapid postwar changes in income and in the relative supplies of food and nonfood commodities and (2) availability of unusual sources of purchasing power over and above current income.

Record quantities of food had been consumed at controlled prices during the war, with the peak coming in 1946 when very large supplies were available for civilians, prices were still controlled

TABLE 5.—*Rough approximations of distribution of individuals by consumer-unit disposable incomes in selected years; 1941 survey pattern of per capita incomes and food expenditures adjusted to consumers' price index of 133; weighted averages of disposable incomes and food expenditures in selected years, and ratios between them*

Total disposable income per consumer unit[1]	Approximate proportion of individuals[2]					Estimated average per capita, 1941 survey pattern adjusted to CPI of 133[3]		
	1935-36	1941	1943	1946	1948	Disposable income	Food expenditures	Percentage of income
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Dollars*	*Dollars*	*Percent*
Under $500	11	3	3	3	3	122	100	82
500 to 999	17	10	7	6	6	293	150	51
1,000 to 1,499	20	10	10	8	9	446	189	42
1,500 to 1,999	16	13	14	11	10	529	194	37
2,000 to 2,999	19	24	23	22	27	734	241	33
3,000 to 4,999	12	27	27	32	28	1,008	284	28
5,000 and over	5	13	16	18	17	2,027	406	20

Item	Weighted average at consumers' price index of 133				
	1935-36	1941	1943	1946	1948
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Average real disposable income per capita[4]	599	858	908	964	939
Average expenditure for food and alcoholic beverages	206	249	257	265	262
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
Percentage of income					
Total	34	29	28	27	28
Alcoholic beverages[5]	3	4	4	5	4
Food	31	25	24	22	24

[1]Money and nonmoney income; dollar values set 33 percent above 1935-39 average.

[2]Estimated by author with assistance of Nathan Koffsky, Selma Goldsmith, and Richard Butler, using data from *Study of Consumer Incomes for 1935-36, Study of Family Spending and Saving* data and Office of Price Administration estimates for 1941 and 1943, and data of the Census Bureau and the Council of Economic Advisers for 1946 and 1948. All distributions in terms of dollars at consumers' price index of 133 percent of 1935-39 average.

[3]The 1941 survey pattern of average incomes and food expenditures given in table 1 was adjusted from the price level 5 percent above the 1935-39 average, to a price level 33 percent above that average, in order to be on same dollar-value basis as the income distributions and to match data previously developed on per capita food consumption by income level.

[4]Derived from adjusted 1941 survey pattern. Averages for 1943 and 1946 appear to be 5 to 10 percent low, in comparison with averages derived from aggregate national income data, because of somewhat higher average incomes within income groups, particularly the much higher average for the group with incomes over $5,000. This understatement of income would be accompanied by some understatement of food expenditures; therefore, the derived proportion of income spent for food is regarded as a reasonable estimate, under the conditions imposed.

[5]Estimated from 1941 survey data.

for part of the year, and demand for food was exceedingly strong. Civilian per capita food consumption in that year averaged 19 percent above the prewar average. Not all of this food was eaten in the calendar year 1946. Some went to restock pantry shelves as well as those distribution channels for which no inventory data are available.

Then in 1947 apparent consumption of food per person declined to an index of 115, but retail food prices averaged 21 percent higher than in 1946. A possible explanation of the precipitous rise in food prices after decontrol in 1946, as well as their high levels in 1947 and 1948, is the fact that many consumers, particularly those of low and medium incomes, were willing to spend increasingly more money if necessary in order to continue to buy the quantity, the quality, and the kinds of foods they had become accustomed to buying in the preceding years of high incomes and controlled prices, or that they had wanted and couldn't buy because of restricted supplies and official and unofficial rationing during the war. After the middle of 1948 there was a gradual change in per capita rates of civilian consumption of most individual foods toward those of the prewar high-income years, and the proportion of disposable income spent for food also declined significantly.

Contributing to the lag in adjustment of food-consumption patterns and food prices was the availability to many families of unusually large liquid assets, the relaxation of controls on consumer credit, the opportunity to reduce the rate of savings, as was done, and the continued shortage of some durable items of high cost, such as cars and houses. The use of liquid assets and consumer credit to buy consumers' goods and services rep-

resented, in the first instance, a net addition to the purchasing power available from current income. Later, this purchasing power was incorporated, at least in part, in the flow of the income stream and included in disposable income of other individuals, corporations, and Government. Accordingly, for a year such as 1947, the average disposable income understates the purchasing power of consumers and leads to a disproportionately high estimate of the ratio of food expenditures to purchasing power.

The use of liquid assets and the opportunity to increase consumer debt were particularly significant for low- and moderate-income families, in 1947-49. With such supplemental purchasing power many were able to keep up their high wartime rate of expenditure for food and other nondurable goods even while they increased their purchases of durable goods. Data from the 1950 Survey of Consumer Finances indicate that among those spending units that were reducing liquid assets in 1949, 49 percent of the units with incomes under $2,000 reported using at least part of their liquid assets for food, clothing, and nondurable goods, compared with 31 percent for the $2,000 to $4,999 income group and 17 percent of those units with incomes over $5,000.[11] The extra purchasing power available for food apparently contributed substantially to the higher level of food expenditures in relation to income, in 1947 compared with 1941, and to the reduction in the "static income-elasticity of demand" indicated in figure 1.

Surveys of consumer finances made for the Federal Reserve Board indicate that record amounts of liquid assets, which had been accumulated during the war and immediately thereafter, were reduced significantly from 1947 to 1950—from $470 per spending unit early in 1947, to $350 a year later, $300 early in 1949, and $250 in 1950. The reduction was about $39 per person in 1947 and $16 in both 1948 and 1949, and represented an addition of that amount to the purchasing power available from current income. According to the 1949 survey[12] about one-third of the reduction in 1947 went directly into nondurable goods and services and one-fifth for automobiles and other durable goods.

Another important source of funds for consumers' expenditures in 1947-49 was the rapid expansion in consumer credit as controls over consumer credit were relaxed after the war. Outstanding consumer indebtedness increased $3.2 billion in 1947, $2.5 in 1948, and $2.4 in 1949. The increase of $3.2 billion in 1947 amounted to $22 per capita.

The total of the reduction in liquid assets and use of consumer credit in 1947 amounted to about $61 per person, in 1949 to $32. The addition of this extra purchasing power to current disposable income brings total purchasing power per capita for 1947 up to $1,231, and to $1,281 in 1949. This makes a significant change in the ratio of food expenditures to purchasing power, from the 29.9 percent, based on adjusted Commerce data, to 28.4 percent in 1947, and 28.5 to 27.8 percent in 1949.

Expenditure and savings data of the Department of Commerce indicate the unusual character of the income-expenditure-savings relationships in the immediate postwar years.[13] Although disposable personal income rose $10.6 billion from 1946 to 1947, the rate of savings declined $8 billion. Expenditures for personal consumption increased $18.7 billion. The increase of $4.8 billion in expenditures for durable goods was to be expected on the basis of deferred demand for such items, but the $9.3 billion increase in nondurables greatly exceeded expectations. Much of this increase was in food expenditures, as already noted. The fact that the decline in the proportion of income going to food in 1948, 1949, and 1950, was not offset by increases in expenditures for other items, but was offset in part by a return to the prewar relationship of savings to high-level disposable incomes, gives further support to the hypothesis that the extraordinarily high expenditures for food in 1947 and early 1948 were due largely to a temporary lag in the adjustment of patterns of consumer-expenditure and savings to a changing situation.

We now consider possible factors contributing to the postwar rate of food expenditures which are likely to be more permanent in duration and most of which appear to indicate some changes in manner of living. Among such factors are movement of population from rural to urban areas, increased "eating out," shifts in channels of distribution, increased consumption of processed foods, greater use of fresh vegetables in "off-seasons," and changes in the age distribution of the population.

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[11]Table 14, Part V, reprinted from Federal Reserve Bulletin for December 1950.

[12]Page 8, part III, of the reprint from the Federal Reserve Bulletin for July 1949.

[13]Excellent discussions of these relationships may be found in two articles in the *Survey of Current Business*, Friend, Irwin, Personal Savings in the Postwar Period, September 1949; Atkinson, L. Jay, the demand for consumers' durable goods, June 1950.

A movement of population from rural to urban areas, such as that which took place between 1941 and 1949, is bound to affect food expenditures and incomes, but the extent is difficult to measure. Obviously, farm families spend less money for food than nonfarm families because they grow some of their own food and the food they buy costs about 10 percent less than the urban prices.[14] But nonfarm incomes average much higher than farm incomes, even on the basis of total disposable income. The problems of definition of net farm income and valuation of home-produced foods make the comparison of urban and rural patterns of income-food expenditure relationships subject to considerable question.[15] However, the proportion of income spent for food was calculated for 1949 using both the January 1, 1941 ratio of farm to total population and the January 1, 1949 ratio, along with the 1941 survey data on farm and nonfarm average money and nonmoney food expenditures and disposable income. (These data had not been inflated to national totals shown by Department of Commerce data.) Use of the 1941 ratio resulted in food expenditures averaging 28.7 percent of reported disposable income whereas the 1949 ratio resulted in 28.3 percent.

This shift from rural to urban areas is not reflected fully in the three adjusted series on food expenditures. The series which was derived from the per capita food-consumption aggregates values all foods at prices paid by moderate-income families in urban areas. The other two series, as adjusted to the concepts of the survey data, value the food for home consumption on farms where produced at a composite rural-urban price.[16] At the most, the difference in prices paid for food arising from the rural-urban shift might account for a $7-increase in the national average of food expenditures, equivalent to about 0.6 of a percentage point in the ratio of food expenditures to income in 1949. The effect on food expenditures of changes in the distribution of the population by income group reflects most of the impact of the rural-urban shift.

One factor in higher postwar food expenditures —increased eating in public restaurants and other institutions—appears to be a significant change in eating habits. The costs of "eating out" include the payment for additional processing, serving, atmosphere, and sometimes entertainment. If a greater proportion of total food consumed is purchased in public eating places, expenditures for food can be higher even without a change in total quantities of food consumed. The increased cost due to this factor was about $8 per person, from 1941 to 1949, equivalent to 0.6 percent of disposable income in the latter year.

Another type of shift in the channels of food distribution which would be expected to affect the level of food expenditures is the shift from lower cost to higher cost distributors in urban areas, such as that from large chain stores to small corner groceries or delicatessens. This factor was probably important during the war but the 1941 pattern of distribution was apparently restored by 1949. For example, chain-store and mail-order food sales accounted for 29.8 percent of total retail sales in 1941, 25.4 percent in 1944, 29.9 percent in 1948, and 31.7 percent in 1949.

In the discussion of the retail-value or food-expenditures series derived from the per capita consumption and retail food price indexes, mention was made of the additional cost of processed food in postwar years compared with a prewar year. The increase between 1939 and 1947 which had not been accounted for in the derived series is estimated at about $7 per capita (excluding the increase in cost of offals). Analysis of the shifts from fresh to processed foods reflected in the consumption index for 1941 and for 1949 is the basis for an estimate of $5 for the remaining part of the additional cost (in 1949 prices). The pattern of fresh versus processed foods in 1939 was probably not greatly different from that of the 1941 survey of family food consumption, nor was 1947 much different from 1949 for the foods in the omitted category.

Accordingly, we may conclude that the total increase in food expenditures from 1941 to 1949, due to shifts to foods processed outside the home (except in public eating places) might amount to $12 per person or 1 percent of disposable income. But at this point we recall that some of the shift from fresh to processed foods would be expected to result from increased incomes. An item-by-item analysis of income-expenditure patterns is the basis for the

[14]See p. 161 of the article by NATHAN KOFFSKY, FARM AND URBAN PURCHASING POWER in volume II of Studies on Income and Wealth.

[15]Margaret G. Reid, in intensive research in this area, has found evidence of similarity between the rural and urban patterns when major farm expenses are spread over several years and apparent variations in incomes are averaged out.

[16]Combining the prices paid by farmers, BAE index, for rural segment of the population and the BLS retail food prices for the urban population.

estimate that about three-fifths of this rise in food expenditures for processed foods is due to higher incomes, and two-fifths is due to the trend toward increased processing outside the home, which is a continuing change in food marketing.

In order to learn the possible effect on food expenditures of somewhat greater consumption of foods in "off-seasons" (from local production), available data on changes in seasonal production of several foods were studied. The only item showing a significant change was truck crops for fresh market. Even here, the increase in output in the winter season, from 1941 to 1949, totaled less than 10 pounds per capita and the increased cost totaled only about 15 cents.

The substantial increase in the birth rate during the last 11 years leads one to consider the effect of a larger proportion of children on food expenditures. The increased consumption of prepared baby foods and of dairy products has already been accounted for. As to other commodities, it might well be argued that this change in age makeup might contribute to lower rather than to higher food expenditures.

To summarize, on the basis of changes in average income and distribution of income we would have expected 24 percent of disposable income in 1949 to have been spent for food, instead of the 28.5 percent indicated by the adjusted Commerce Department food expenditure data, 25.7 percent indicated by the adjusted series on retail cost of farm food products, and 27.7 percent by the derived series (including additional processing and offals). If we add to the 24 percent figure the effects of the enduring, dynamic factors, roughly 0.6 percent for the rural-urban shift (not already accounted for by income changes), 0.6 percent for increased costs of eating out, and 0.4 percent for the extra costs of processing in 1949 as compared with 1941 and not due to higher incomes, we obtain 26 percent as the estimated relationship of food expenditures to disposable income. Furthermore, we should take into consideration the additional $33 of purchasing power (1949 dollars) available per person in 1949 from the use of liquid assets and consumer credit. This would increase the derived ratio of food expenditures to available purchasing power by another 0.7 percent and bring it surprisingly close to the ratios derived from the three dynamic series. The proportion of current income spent for food in 1950 was again lower than in the preceding year, indicating further adjustment in the income-food expenditure relationship toward the long-time pattern. Moreover, the outbreak of hostilities in Korea undoubtedly encouraged extra buying to increase the stocks of food in households.

Conclusions

We may draw three conclusions from the foregoing analysis.

(1) Engel's law probably applies reasonably well to the relationship of national averages of income and food expenditures through periods in which no substantial changes take place in population patterns, distribution of income, manner of living, and marketing practices. That is to say, it applies under conditions that are relatively static and are similar to the circumstances in which Engel formulated his law.

(2) In the wartime and immediate postwar years certain forces arising from the war materially altered the peacetime pattern of national averages of income and food expenditures. Some of these carried over as far as 1949, although they were essentially temporary in character. The most significant were the supplemental sources of total purchasing power and the diversion of an unusually large proportion of that purchasing power to food, as long as supplies of durable goods, particularly the expensive items, failed to meet the potential demand. These forces increased the dynamic elasticity of demand by raising the level of food expenditures and decreased the static income elasticity of demand by raising the food expenditures of lower- and moderate-income families more than those of families of higher income.

(3) Two dynamic forces active in 1941-50 are likely to have a lasting effect on the relationship of aggregate food expenditure to income: the shift of population from rural to urban areas and the change in manner of living reflected in increased processing of food outside the home, either in public eating places or in processing plants. These forces appear to have increased the dynamic income elasticity of demand for food by raising the general level of food expenditures. Lacking sufficient basis as yet for ascertaining the contribution of these enduring forces to the lower static income elasticity of demand that is evident in the 1947 urban data compared with 1941, we cannot estimate their possible offsetting effect upon future dynamic income elasticity of demand for food.

AGRICULTURAL ECONOMICS RESEARCH

A Journal of Economic and Statistical Research in the
United States Department of Agriculture and Cooperating Agencies

Volume VIII | APRIL 1956 | Number 2

How Research Results Can Be Used To Analyze Alternative Governmental Policies

By Richard J. Foote and Hyman Weingarten

Since 1952, several technical bulletins[1] that deal with the demand and price structure for grains have been published by the United States Department of Agriculture. Research results from three of these bulletins can be used in an integrated way to consider possible effects of alternative governmental price-support policies for wheat and corn. This article discusses the ways in which such analyses can be made, with emphasis on the effects of alternative assumptions on the conclusions reached. It demonstrates the power of the modern structural approach for studies of this sort. Results obtained and conclusions reached in this article come directly from the application of certain systems of economic relationships based on specified assumptions. Although it is believed that these results and conclusions throw light on the alternative policies analyzed, they in no sense represent official findings of the United States Department of Agriculture. They are presented primarily to illustrate the kinds of analyses that can be made from an approach of this sort.

TWO SETS of statistical analyses are basic for the studies reported in this article, and these are supplemented by certain other analyses. The first set of analyses is an equation that shows the effect of certain factors on the price of corn from November through May, when marketings are heaviest. The other set is a system of 6 equations that shows the simultaneous effect of 14 given variables on domestic and world prices for wheat and on domestic utilization for food, feed, export, and storage of wheat for the July to June marketing year. The supplemental analyses include studies of (1) normal seasonal variation in prices and (2) relationships among prices at local and specified terminal markets. These are mentioned in later sections.

The analysis for corn is described in detail on pages 5 to 12 of Technical Bulletin 1070. It was based on data for the years 1921–42 and 1946–50. The following variables were used:

- X_0—price per bushel received by farmers for corn, average for November to May, cents.
- X_1—total supply of feed concentrates for the year beginning in October, million tons.
- X_2—grain-consuming animal units fed on farms during the year beginning in October, millions.
- X_3—price received by farmers for livestock and livestock products, index numbers (1910–14=100), average for November to May.

The following regression equation applies:

$$\text{Log } X'_0 = -0.95 - 1.82 \log X_1 + 1.71 \log X_2 + 1.36 \log X_3 \quad (1)$$

[1] Foote, Richard J., Klein, John W., and Clough, Malcolm, the demand and price structure for corn and total feed concentrates, U. S. Dept. Agr. Tech. Bul. 1061, 1952. Foote, Richard J., statistical analyses relating to the feed-livestock economy, U. S. Dept. Agr. Tech. Bul. 1070, 1953. Meinken, Kenneth W., the demand and price structure for oats, barley, and sorghum grains, U. S. Dept. Agr. Tech. Bul. 1080, 1953. Meinken, Kenneth W., the demand and price structure for wheat, U. S. Dept. Agr. Tech. Bul. 1136, 1955.

For any given year, if expected values for X_2 and X_3 are inserted, this equation can be written in the following way:

$$\text{Log } X'_0 = \log A_1 - 1.82 \log X_1 \qquad (1.1)$$

where $\log A_1 = -0.95 + 1.71 \log X_2 + 1.36 \log X_3$ for that year. In the rest of this paper, the form shown by (1.1) is used. The reader should remember, however, that the applicable value for $\log A_1$ must be obtained from equation (1).

The analysis for prices of corn makes no direct allowance for the effect of a price-support program. It is primarily of value in indicating prices that would be expected under free-market conditions if given supplies of feed concentrates were available. If prices under a support program are expected to be higher than those indicated by the analysis, the analysis suggests that part of the supply will need to be held off the market under the program, although it does not indicate directly how much must be removed.

The system of equations for wheat is described in detail on pages 36 to 50 of Technical Bulletin 1136. The analysis was based on data for the years 1921–29 and 1931–38. These are years for which direct price-support activities of the Government are believed to have had only minor effects on prices and utilization. The system can be used, however, to indicate probable effects on utilization of various types of price-support programs. Because of space limitations, a list of all variables taken as given for this system of equations cannot be included here. The list contains such items as supply of wheat, consumer income, freight rates, numbers of poultry on farms, and other variables that are believed to be affected only slightly, if at all, by economic factors not specified in the system of equations used to explain prices and utilization of wheat during a given marketing year. Included among these given variables is the price of corn, but, as is shown later, the system can be modified to include corn prices among the variables that are simultaneously determined within the system.

Variables that are assumed to be determined simultaneously within the original system of equations for wheat include the following—the symbolic letters are basically the same as those in Technical Bulletin 1136:

P_w—wholesale price per bushel of wheat at Liverpool, England, converted to United States currency, cents.

P_d—wholesale price per bushel of No. 2 Hard Winter wheat at Kansas City, cents.

C_f—domestic use of wheat for feed, million bushels.

C_e—domestic net exports of wheat and flour on a wheat equivalent basis, million bushels.

C_s—domestic end-of-year stocks of wheat, million bushels.

C_h—domestic use of wheat and wheat products for food by civilians on a wheat equivalent basis, million bushels.

All variables relate to a marketing year beginning in July. C_s is assumed to apply to stocks held in commercial hands. When a price-support program is in effect, end-of-year stocks under loan or held by the Commodity Credit Corporation are computed as a residual.

P_w is assumed to depend directly on certain given variables, hence its value in any year can be obtained by a direct solution of a single equation similar to equation (1) for corn. It then can be treated as though it were given. The values of the given variables and the calculated value of P_w for any year can be substituted in each equation. By making computations similar to those used in obtaining $\log A_1$, new constant terms can be obtained for each equation. The equations then can be written conveniently in the following form. These equations bear the same relation to the original equations as equation (1.1) does to (1).

$$C_h + C_f + C_e + C_s = A_2 \qquad (2)$$

$$C_h + 0.0015LP_d = LA_3 \qquad (3)$$

$$C_f + 2.5P_d = A_4 \qquad (4)$$

$$C_e + 7.8P_d = A_5 \qquad (5)$$

$$C_s + 411(P_d/I_d) = A_6 \qquad (6)$$

Two given variables are involved in these equations. They are (1) L, the total population eating out of civilian supplies, in millions, and (2) I_d, wholesale prices of all commodities in this country as computed by the Bureau of Labor Statistics (1926=100). They cannot be included in the modified constants because they appear as a multiplier or divisor, respectively, of P_d.

By subtracting the last 4 equations from equation (2) and solving the resulting equation for P_d, the following formula is given:

$$P_d = \frac{A_2 - LA_3 - A_4 - A_5 - A_6}{-0.0015L - (411/I_d) - 10.3} \qquad (7)$$

Once a value for P_d is obtained, equations (3) to (6) can be solved directly, after inserting values for L and I_d, to obtain the 4 price-determined utilizations.

We are now ready to discuss how these analyses can be used to answer specified policy questions. Four types of questions are considered.

Effects of Eliminating Price Supports for Wheat While Retaining Them for Corn

For a number of commodities, the price-support program is retained at full rates only if a specified percentage of producers vote in favor of marketing quotas. This is true for wheat. In the spring of 1955, many people believed that producers might vote down marketing quotas for wheat; there is always the possibility that this might happen in later years. Questions were therefore raised as to what might happen to wheat prices if quotas were defeated. As no marketing quotas were involved for corn, it was logical to assume that the current support program would remain unchanged. From an analytical standpoint, this simplified the computations because, in the study for wheat, corn prices could be taken as given.

At the time the analysis was made, producers already had accepted quotas for the 1956 crop. Hence, the earliest year for which quotas could be rejected was the marketing year beginning in 1957. Separate estimates were made for each year beginning July from 1957–58 through 1960–61. On a judgment basis, it was assumed that production of wheat, with no restrictions on acreage, might increase to 1,080 million bushels, compared with 860 million bushels in 1955. Commercial stocks on July 1, 1957, were taken at 60 million bushels, about the same as for the same date in 1955; and it was assumed that stocks held under the support program could be impounded in such a way that farmers and members of the trade would know that these stocks would *not* affect domestic or world prices of wheat. In a study discussed in a later section of this article, an indication is given as to what might happen to prices if these stocks were released or "dumped" directly into commercial channels.

Prices of corn were taken at levels equivalent to those that might be expected under the support program if it were operated under existing legislation, assuming no change in the parity index from the level of mid-1955. A gradual decline in the price of corn was indicated, reflecting a continued build-up in supplies and a shift from "old" to "new" parity. Expected supplies of wheat in this country, less stocks impounded, were used in deriving expected world supplies, and population, poultry units, and "time" were based on expected values for the given years. Other given variables were taken at the same level as in 1954–55, the latest year for which data were available at the time of the study. The analysis is thus based on the assumption that economic conditions outside the grain economy shall remain at about the current level.

Two modifications in the system of equations shown on p. 34 were made.

The first involves the substitution of a curvilinear relationship between prices of wheat and the quantity of wheat fed to livestock for the linear relationship that is believed to apply when the spread between the price of wheat and the price of corn used in the analysis is between zero and 40 cents per 60 pounds (the weight of a bushel of wheat). For larger price spreads, requirements for wheat in poultry and other rations is more than the quantity indicated by the linear analysis. Thus, when use for feed is plotted on the vertical scale, a slope that becomes less steep is required. When the price of wheat approaches or falls below the comparable price of corn, use of wheat for feed increases rapidly and by more than that suggested by the linear relationship. For this part of the curve, a slope that becomes increasingly steep is required. When the price spread is outside the specified range, the quantity of wheat fed frequently can be estimated approximately by making use of a logarithmic relation between prices of wheat and quantity fed. This computation is described in detail on pages 89 to 93 of Technical Bulletin 1136.[2] Use of a curvilinear relation of this sort was required for all years for the data shown in the upper part of table 1 and for the year beginning 1957 in the lower part of the table. Considerations involved

[2] Computations involved in incorporating results from the logarithmic equation in the system of equations are similar to those discussed on p. 37 involving a similar incorporation of results from the logarithmic analysis for prices of corn.

in developing the logarithmic analysis are described in detail on pages 23 to 25 of the bulletin on wheat.

The second modification concerns equation (5) for exports. Because of the effect of institutional forces in the world today, it is believed that exports from this country that exceed specified levels will result in retaliatory action on the part of other governments. So long as our exports remain below these levels, it is likely that the same kind of economic forces will apply as those in the pre-World War II years on which the analysis was based. This adjustment in the system of equations can be made easily. The equations are first solved with no restriction on exports. If the indicated figure for C_e is higher than the specified maximum, the following formula is used to estimate P_d. In this formula, the symbol E is used to indicate the assumed maximum for exports.

$$P_d=\frac{A_2-LA_3-A_4-E-A_6}{-0.0015L-(411/I_d)-2.5} \qquad (7.1)$$

The reader can easily verify that this formula is obtained by substituting $C_e=E$ for equation (5), then deriving the formula for P_d by the same algebraic process as that used in the previous case. The other utilizations are obtained in the same way as previously. Table 1 shows results from the analysis when E is taken, respectively, as 400 and 300 million bushels. The latter quantity is probably more nearly representative of present-day conditions. Exports of 355 million bushels are indicated for the marketing year beginning in 1957 under the 400-million bushel maximum. This quantity was derived by making use of a price obtained from the original formula (7) for P_d. All of these computations assume the average export subsidy per bushel of wheat to be the same as in 1954–55.

One other minor modification was made to take account of the fact that, when questions of policy are considered, prices received by farmers rather than prices at a terminal market ordinarily are used. By using an analysis described on pages 70 to 71 of Technical Bulletin 1136, estimated prices of No. 2 Hard Winter wheat at Kansas City as obtained from the system of equations were converted to an equivalent price received by farmers. If P_d' is used to represent the price received by farmers in cents per bushel, the relationship is as follows:

$$P_d'=-5.4+0.92\ P_d \qquad (8)$$

TABLE 1.—*Wheat: Estimated price, supply, and utilization with a price-support program for corn but no program for wheat and with stocks of wheat under the loan program as of July 1, 1957, impounded, 1957–60* [1]

Exports restricted to not more than 400 million bushels

Item	Unit	Year beginning July			
		1957	1958	1959	1960
Price received by farmers per bushel.	Cts	195	190	180	175
Supply:					
Production	Mil. bu	1, 080	1, 080	1, 080	1, 080
Beginning stocks	do	60	120	140	160
Total	do	1, 140	1, 200	1, 220	1, 240
Utilization:					
Seed and industrial.	do	75	75	75	75
Food	do	480	475	475	475
Feed	do	110	110	110	110
Export	do	355	400	400	400
Ending stocks	do	120	140	160	180

Exports restricted to not more than 300 million bushels

Item	Unit	1957	1958	1959	1960
Prices received by farmers per bushel.	Cts	175	145	125	115
Supply:					
Production	Mil. bu	1, 080	1, 080	1, 080	1, 080
Beginning stocks	do	60	170	260	310
Total	do	1, 140	1, 250	1, 340	1, 390
Utilization:					
Seed and industrial.	do	75	75	75	75
Food	do	485	490	490	490
Feed	do	110	125	165	190
Export	do	300	300	300	300
Ending stocks	do	170	260	310	335

[1] Impounded stocks are assumed to have no effect on domestic or world prices.

Several inferences can be made from the data shown in table 1. Under the more realistic assumption with respect to exports, prices decline to $1.15 per bushel for the last year shown. As farmers and the trade might anticipate a decline of this kind, it is possible that prices for earlier years would sag below those suggested by the analysis. The analysis suggests that if exports somehow could be increased to around 420 million bushels a year, prices might remain at around $1.90 per bushel, *once present surpluses are disposed of*, even though production controls were eliminated.

This can be compared with the expected price of $2.00 for 1955–56 under the present program. However, even if present "surpluses" were, in effect, completely eliminated, prices apparently would decline rapidly to a relatively low level unless either (1) production controls were retained, or (2) exports could be increased materially. In the table, ending stocks are shown as a residual; in the analysis they were obtained simultaneously with utilization items other than seed and industrial.

Effect of "Elimination of Surpluses" in 1955–56 Given Existing Support Programs

Another question of interest is "What would happen to agricultural prices if we got rid of our burdensome surpluses?" For wheat, a partial answer is given by the preceding example. But we may also ask, What price would prevail during the 1955–56 marketing year if stocks under loan, or held by the Commodity Credit Corporation as of the start of the year, were impounded so as to nullify their effect on market prices? The basic analyses discussed in the first section of this article can be used to provide an answer to this question as it applies to wheat and corn.

On the surface, the problem looks fairly simple. Stocks of wheat other than those in commercial hands on July 1, 1955, were 990 million bushels, and similar stocks of feed grains that enter into the supply of total feed concentrates at the beginning of the 1955–56 marketing season were 30 million tons. The latter includes stocks of oats and barley under loan or owned by the Commodity Credit Corporation as of July 1, and stocks of corn and sorghum grains as of October 1. One might assume that the answer might be reached by deducting these stocks from the total supplies in the respective analyses, inserting expected values for the other given variables, and obtaining expected values for the various dependent variables. But the quantity of wheat fed depends partly on the price of corn, and the price of corn depends to some extent on the quantity of wheat fed. Hence, it seemed desirable to modify the system of equations for wheat so that the price of corn could be included among the simultaneously determined variables.

If the analysis for corn had been based on a linear, rather than a logarithmic, relationship, this could have been done easily. In the next few paragraphs we discuss how a linear relationship was derived from the logarithmic one for corn. The linear relation can be used as an approximation for the logarithmic if changes in X_1 from the initial value are small.[3]

To simplify the discussion, we first rewrite equation (1.1) by substituting the letter b for the numerical value of the regression coefficient. Thus $b = -1.82$. The equation then reads:

$$\log X'_0 = \log A_1 + b \log X_1 \qquad (1.2)$$

If we translate this equation into actual numbers (rather than logarithms) we obtain:

$$X'_0 = A_1 X_1^b \qquad (1.3)$$

We now borrow a notion from differential calculus. To get the slope of a curve at any given point, we need to evaluate the first derivative at that point. The first derivative of the function (1.3) with respect to X_1 is:

$$\frac{dX'_0}{dX_1} = bA_1X_1^{b-1} \qquad (9)$$

Inserting the value for b, we get:

$$\frac{dX'_0}{dX_1} = -1.82A_1X_1^{-2.82} \qquad (9.1)$$

We wish to evaluate the slope of the line when X_1—total supply of feed concentrates—is at its expected level, for the particular analysis, making use of the appropriate value of A_1. As of the start of the analysis, we know all values that enter into X_1 except the quantity of wheat to be fed during the crop year, and that we can estimate approximately. In most instances, an error of as much as 100 percent in our advance estimate of the quantity of wheat fed will affect X_1 by only a few percentage points (as the quantity of wheat fed normally constitutes only about 2 percent of the total supply of feed concentrates) and will affect the estimate of the slope of the line even less. If the initial estimate of the quantity of wheat fed is found to be badly off, after making the computations for the system of equations, so that the computed linear relationship is a poor approximation to the true curve, we can always make a better approximation by using a revised

[3] This general approach is described by ALLEN, R. G. D., MATHEMATICAL ANALYSIS FOR ECONOMISTS, Cambridge Univ. Press, New York, 1947, page 145. It was developed independently in this study by the authors.

value for X_1 and then making a new set of computations for the system.[4] Let us designate the answer obtained from (9.1) as B. The reader should note that logarithms are needed to evaluate the expression $X_1^{-2.82}$.

We now wish to obtain a linear equation that has the slope B and that passes through the point on the original logarithmic curve at the chosen value for X_1. By substituting the estimated value of X_1 in equation (1.1), we can obtain an estimated value for X_0 at that point. Let us designate these numbers by the symbols $\hat{X}_0$, $\hat{X}_1$. We now can write the equation of the desired linear relation as:

$$X'_0=(\hat{X}_0-B\hat{X}_1)+BX_1 \qquad (10)$$

The reader who remembers his elementary analytical geometry will see that this is the equation of a line for which we know the slope and 1 point.

We must now effect some further transformations to make equation (10) apply to the variables included in the system of equations for wheat. For the combined analysis, all of X_1 is assumed to be given except the quantity of wheat fed. This can be allowed for in the equation by letting

$$X_1=X''_1+C''_f \qquad (11)$$

BX''_1 then can be combined with the other constant terms in the equation. The symbol C''_f is used because this is in terms of million tons, while C_f, as used in the system of equations for wheat, is in million bushels. The relationship between C''_f and C_f is given by:

$$C''_f=\frac{60}{2{,}000}C_f \qquad (12)$$

In the system of equations for wheat, the price of corn, P_c, relates to 60 pounds of No. 3 Yellow at Chicago, average for July–December, in cents, whereas X_0 is the average price received by farmers per standard or 56-pound bushel, average for November–May, in cents. A relationship between P_c and X_0 can be developed in several ways, one of which follows: (1) Based on the computation discussed on page 12 of Technical Bulletin 1070, the season-average price received by farmers for corn equals approximately $X_0/0.95$. (2) Based on an analysis referred to on page 65 of Technical Bulletin 1061, the annual average price of No. 3 Yellow corn at Chicago equals the annual price received by farmers for all corn times 1.05 plus 1.11 cents. (3) Based on index numbers of normal seasonal variation for No. 3 Yellow corn at Chicago as shown on page 50 of that bulletin, the July–December price at Chicago equals 1.017 times the annual price. (4) The price of 60 pounds of corn naturally equals 60/56 times the price of a standard bushel. By combining these relationships, we find that

$$X_0=0.83P_c-1.004 \qquad (13)$$

If we make the three substitutions implied by equations (11), (12), and (13), we can rewrite equation (10) as

$$P_c=1.2(\hat{X}_0-B\hat{X}_1+BX''_1+1.004)+0.036\,BC_f \qquad (10.1)$$

By letting $A_7=1.2(\hat{X}_0-B\hat{X}_1+BX''_1+1.004)$ and $b_{71}=0.036B$, we can rewrite this as

$$P_c=A_7+b_{71}C_f \qquad (10.2)$$

The equation in this form is used in the rest of the discussion. In following it, one should keep in mind the substantial number of computations involved in obtaining A_7 and b_{71}.

We are now ready to consider the system of equations that includes (10.2). Referring to page 34, if equations (3), (5), and (6) are subtracted from equation (2), equation (14) shown below is given. Equation (4) now must be modified to show P_c as a separate variable. This is done by removing $2.5P_c$ from A_4 and transposing this term to the opposite side of the equality sign. The modified equation is designated as equation (4.1) in the system shown below, and the modified A_4, as A'_4. Equations (14), (4.1), and (10.2) can be written conveniently as follows:

$$\begin{array}{lllll}
C_f-(0.0015L+7.8+411/L_d)P_d & & & =A_2-LA_3-A_5-A_6 & (14)\\
C_f & +2.5P_d & -2.5P_c & =A'_4 & (4.1)\\
-b_{71}C_f & & +P_c & =A_7 & (10.2)
\end{array}$$

If equation (10.2) is multiplied by -2.5 and subtracted from equation (4.1), the following equation results:

$$(1-2.5b_{71})C_f+2.5P_d=A'_4+2.5A_7 \qquad (15)$$

If equation (14) is multiplied by $(1-2.5b_{71})$ and subtracted from equation (15), a formula for P_d can be derived directly. To write this in algebraic symbols is somewhat complicated but, when working with numbers in an actual problem, it would

[4] In the analyses discussed here, three iterations normally were required to verify that the answers were correct to the nearest cent on prices and the nearest million bushels on utilization.

be very simple. A value for C_f then can be obtained from equation (14), P_c can be obtained from equation (10.2), and the other price-determined utilizations for wheat can be obtained easily from the initial equations.

This approach was used to estimate the effects on prices of wheat and corn if stocks controlled by the Government as of the start of the 1955–56 marketing year were impounded so that they could not affect domestic or world prices. Results are shown in table 2. The stocks impounded are shown in the row for Government stocks. To show the effect of export subsidies, two sets of computations were made. One assumes the same average export subsidy per bushel as in 1954–55, whereas the other assumes no export subsidies. Prices shown in the last column are those that are expected by commodity analysts to prevail under the support programs in 1955–56. Utilization for food, feed, export, and commercial carryover were obtained from the system of equations, making use of the expected levels of prices for wheat and corn. Government stocks were taken as a residual. In making these computations, export subsidies were assumed to be at the same rate per bushel as in 1954–55. In all instances, quantitities fed were computed by making use of the logarithmic analysis referred to on page 35.

Comparison of the prices shown in the first and last columns suggests that stocks controlled by the Government are fairly effectively isolated from the market under existing conditions. Their complete elimination, as implied by the first set of computations, would result in price increases of not more than 10 percent.

The average export subsidy in 1954–55 was 38.5 cents per bushel. This was computed by taking subsidies paid per bushel under the International Wheat Agreement times the number of bushels shipped under the agreement and dividing by total exports during the marketing year. Comparison of the prices shown in the first 2 columns of table 2 suggests that prices of all wheat might decline by about 25 cents a bushel if this subsidy were eliminated, but that prices of corn would be approximately unaffected. The analysis suggests that exports with no subsidy would decline substantially.

The reader may question why commercial stocks, as shown in the last column, are so much higher than those shown in the first column, whereas all other price-determined utilizations are about the same in the two columns. This reflects a number of factors. Use for food and feed are nearly the same because demand for each under the conditions specified is highly inelastic. Exports are about the same because, whereas domestic prices are somewhat lower in the last than in the first column, world prices as estimated from the system of equations also are lower when all stocks are included in supply; the difference between world and domestic prices affects exports rather than the level of either series separately. Thus the only series which reflects much change as a result of the lower domestic prices is the level of stocks. Commercial stocks on July 1, 1956, are likely to be lower than the 110 million bushels suggested by the system of equations, but exports probably will be larger than the 170 million bushels indicated because of special Governmental programs not taken into account by the system.

TABLE 2.—*Estimated prices of wheat and corn and utilization of wheat with Government stocks as of the beginning of the 1955–56 marketing year impounded, as compared with expected values under existing conditions, marketing year beginning 1955* [1]

Item	Unit	Stocks impounded and export subsidy at—		Existing conditions with export subsidy at same level as in 1954–55
		Same level as in 1954–55	Zero	
Price received by farmers per bushel:				
Corn	Cts	130	130	125
Wheat	do	220	195	200
Wheat:				
Utilization:				
Food	Mil. bu	500	505	505
Feed	do	105	110	105
Export	do	175	95	170
Seed and industrial	do	75	75	75
Ending stocks:				
Commercial	do	60	130	110
Government	do	990	990	[2] 940

[1] Stocks impounded are assumed to have no effect on domestic or world prices.
[2] Residual.

Effect of Eliminating Price Supports for Both Wheat and Corn

Another kind of analysis that can be made is to estimate free-market prices for commodities currently in surplus under assumptions such as (1) that all stocks under loan or held by CCC are dumped on the market in a single year; and (2) that these stocks are disposed of in such a way as to have no effect on market prices. As we can think of no way in which such a disposal could be carried out, the second assumption is reworded to conform to that in previous examples, that is, that stocks are impounded in such a way as to have no effect on domestic or world prices.

Estimates were made for marketing years beginning in 1956 and in 1959, with all dumping assumed to take place in 1956. The year 1959 was chosen to allow for some longer range adjustments. In some instances, estimates for wheat and corn also were made for intervening years; results shown here are for the 2 periods only. We naturally assumed that acreage controls were eliminated. Basic assumptions of the magnitude of certain supply variables are shown in table 3, together with results of the analysis. For all estimates, the general level of economic activity was taken to be the same as that prevailing in 1953–54. Subsequent tests compared results based on this level with those obtained under conditions prevailing in 1954–55. Only minor differences were indicated.

In deriving A_1, the number of animal units with Government stocks impounded was assumed to be the same as the expected number for 1955–56; with Government stocks included in the commercial supply, an increase of 6 percent above 1955–56 was assumed. This is about as large an increase as would be expected in a single year under the assumed conditions. To estimate an associated price for livestock products, this number of animal units was used in an equation given on page 21 of Technical Bulletin 1070, assuming no change in disposable income from the level of the previous year. These 2 variables—animal units and prices of livestock products—are involved in the computation of A_1.

Results shown in columns 1 and 3 of table 3 were obtained directly from the system of equations. An adjustment for feed of the kind described on p. 35 should have been made for the year beginning in 1956, with Government stocks impounded, but the resulting error was believed to be so small that further manipulation of the model was regarded as unwarranted. A figure of around 100 million bushels probably would have been obtained instead of 75 million bushels as shown in the table.

When Government stocks were assumed to be sold through commercial channels for the year beginning in 1956, and exports were restricted to not more than 400 million bushels, a direct solution of the equations gave a price estimate of 3 cents a bushel for wheat at Kansas City and 93 cents for corn at Chicago. The reason for this implausible result is as follows: When the price of wheat falls to near or below that for corn, the demand for wheat for feeding is much more elastic than when the price is considerably above that for corn. The logarithmic analysis for wheat fed could not be used in this instance because the logarithm of a negative number is undefined. The following method was used instead: A 20-cent negative differential between prices received by farmers for wheat and corn seemed like a maximum, and the regression coefficient for (P_d–P_c) in equation (4.1) was adjusted in such a way as to reduce the negative price differential to this level.[5]

The algebra involved in obtaining the adjusted coefficient is rather complicated and need not be shown in detail here. The general approach is as follows: (1) By making use of the relationships previously described between prices received by farmers and prices at specified terminal markets, the algebraic value for P_d–P_c that is equivalent to a negative spread of 20 cents at the farm level can be obtained. Let this algebraic value equal M. (2) Equation (4.1) (see p. 38) is modified to substitute a regression coefficient for P_d–P_c that is unknown for the value of 2.5 used under normal circumstances. Call this coefficient K. (3) M is substituted for P_d–P_c in equation (4.1) and P_d–M is substituted for P_c in equation (10.2). This eliminates P_c from the equations.

[5] A negative differential of this magnitude seems reasonable if supplies of wheat available for feeding relative to demand are expected to be extremely large. In certain analyses made after the writing of this article, supplies of wheat available for feeding were expected to be much larger than normal but the demand for feed also was expected to be abnormally large. Here a zero differential between P_d and P_c was used, that is, P_d was not permitted to be less than P_c. The basic algebraic formulation is the same in either case.

TABLE 3.—*Estimated price, supply, and utilization of wheat and feed concentrates with no price-support operations, marketing years beginning 1956 and 1959*

Item	Unit	With Government stocks at the beginning of the 1956 marketing year—				
		Impounded [1]		Included as part of total supply		
		1956	1959	No restriction on exports, 1956	Exports restricted to not more than 400 million bushels: 1956	Exports restricted to not more than 400 million bushels: 1959
Price per bushel received by farmers:						
Wheat	Cts	165	124	88	56	115
Corn	do	119	115	87	76	114
Wheat:						
Production	Mil. bu	1, 160	1, 160	1, 160	1, 160	1, 160
Stocks	do	50	300	925	925	355
Total supply	do	1, 210	1, 460	2, 085	2, 085	1, 515
Utilization:						
Seed and industrial	do	86	86	86	86	86
Food	do	479	495	506	515	498
Feed	do	75	177	204	601	205
Export	do	375	400	890	400	400
End-of-year storage	do	194	302	398	483	327
Feed concentrates:						
Production of feed grains	Mil. tons	120	120	120	120	120
Wheat fed	do	2	5	6	18	6
Other feeds fed	do	24	24	24	24	24
Stocks	do	12	12	35	35	9
Total supply	do	158	161	185	197	159
Utilization:						
Feed	do	130	133	146	156	133
Food, industry, seed, export	do	16	16	21	21	16
End-of-year storage	do	12	12	18	20	10
Grain-consuming animal units [2]	Mil	174	176	183	183	182
Feed fed per animal unit [2]	Tons	. 75	. 76	. 80	. 85	. 73

[1] Impounded stocks are assumed to have no effect on domestic or world prices.

[2] Livestock numbers and rates of feeding are based on estimates made prior to the recent revisions based on 1954 census data.

(4) Equations (14), (4.1), and (10.2) now contain 3 unknowns—C_t, P_d, and K. As some of the equations may be nonlinear, part of the solution of them may need to be made graphically. Once values for C_t, P_d, and K have been obtained, the other desired unknowns can be obtained easily. A regression coefficient of 11 instead of 2.5 was used in obtaining the estimates shown in the next to the last column.

Estimates for the year beginning in 1959, when Government stocks are impounded, are based on a beginning carryover of 300 million bushels of wheat. This quantity was chosen, after some experimentation, because it appeared to represent an equilibrium; ending stocks, as derived from the system of equations, are 302 million bushels.

Data shown in the last column were obtained year by year by using the following general approach: (1) The number of animal units to be fed was estimated by commodity specialists on our staff, making use of the estimates of feed prices and carryover of feed concentrates from the statistical analysis for the previous year. Originally, we had expected to make these estimates from an

equation described on page 14 of Technical Bulletin 1070, but this appears to be no longer applicable.[6] (2) An associated price for livestock was obtained in the way described on p. 40. (3) These results were used to obtain an estimate of A_1, and the remaining computations were carried out in the usual way, using as beginning stocks the carryover from the preceding year.

End-of-year carryover for wheat decreased continuously and was still decreasing in 1959. Hence, somewhat higher prices than those shown for the year beginning in 1959 would be anticipated at a long-run equilibrium level. Utilization estimates for feed were made on a judgment basis by Malcolm Clough of our staff taking into consideration probable livestock numbers and the rate of feeding per animal unit with the given feed grain supplies and the derived prices of feed. The carryover for feed was taken as a residual, except for a restriction that stocks could not fall below a minimum working level.

Results shown in table 3 with Government stocks impounded can be compared with those in the upper section of table 1 to indicate the effect of a price-support and acreage-control program for corn and other crops on the price of wheat. Contrary to what might be expected on first thought, production of wheat was assumed to average around 1,080 million bushels with controls for other crops and to increase to 1,160 million bushels if these controls were eliminated. This assumed change grows out of a consideration of the effects of acreage controls on other crops that compete for land with wheat. When allowance is made for the expected difference in production of wheat, price supports and acreage-control programs for other crops apparently affect the price of wheat considerably. If a comparison that makes no allowance for a change in production of wheat is desired it can be obtained by comparing the data in table 3 with those in the lower section of table 1, as a difference of 100 million bushels for export would about compensate for the 80-million bushel difference in production. When the comparison is made in this way, prices for wheat when a program is in effect for corn are found to be only slightly higher than prices for wheat when no program exists for corn.

[6] The animal unit series is a weighted aggregate of the various groups of livestock on farms. More reliable projections of the total number of animal units can be derived by obtaining individual estimates of livestock numbers from the livestock commodity specialists, and combining these into the animal unit series, than by deriving the aggregate number from statistical relationships. This is especially true if the projection is made for only a year or two ahead, as reports on plans of farmers and current trends in numbers can be taken into account. For more distant projections, the statistical equations might yield better results than those obtained on a judgment basis.

Effects of a Multiple-Price Plan for Wheat

On pages 49 to 50 of Technical Bulletin 1136, Meinken describes how his system of equations can be used to study the effect of multiple-price plans. Suppose a 2-price plan is in effect under which wheat used for domestic food consumption is sold at a price equivalent to 100 percent of parity, while the remaining wheat sells at a free-market price. The amount of wheat used for food could be estimated from equation (3) (see p. 34) based on a value for P_d equivalent to the parity price. Suppose this amount is $\hat{C}_h$. The equation $C_h=\hat{C}_h$ is substituted for equation (3), and the system is solved for the other variables in the same way as described on p. 34.

If the Government were to place a floor under the "free" price at say 50 percent of parity, an estimate of the quantity of wheat going under the support program at this price, if any, could be obtained as a residual after computing the expected utilizations and commercial carryover. If the Government established a price for wheat used for food and a lower price for wheat used for feed, an approach similar to that described above could be used to solve for the expected utilizations for food and feed and the free-market price at which the remaining wheat would sell. Computations of this sort are relatively easy, but, as with the other analyses discussed in this study, many assumptions must be made.

Summary

This article describes four types of policy questions for wheat and corn that can be analyzed by using the research results contained in three recently-issued technical bulletins. Emphasis is placed on the algebraic manipulations required to allow for special circumstances. It is believed by some economic analysts that mathematical systems

of equations are inflexible and difficult to adjust to allow for special circumstances; cases described in this article show this not to be true. Structural models are highly flexible and they can be modified to allow for many special circumstances. Moreover, results from the analysis can be combined with judgment estimates on the part of commodity specialists when this appears desirable. The advantages that a structural analysis of this kind has over one based entirely on judgment are that all interrelated estimates automatically are consistent, one with another, and account automatically is taken of those statistical relationships that are believed to be valid.

AGRICULTURAL ECONOMICS RESEARCH

A Journal of Economic and Statistical Research in the United States Department of Agriculture and Cooperating Agencies

Volume VIII JULY 1956 Number 3

The Long-Run Demand for Farm Products

By Rex F. Daly

No one knows exactly what the demands for farm products will be in 1960 and 1975. Nor can anyone foresee the exact supplies of agricultural commodities in these years. Yet farmers, legislators, and administrators of agricultural programs cannot work entirely in the dark. They must base their plans upon the best possible estimates of future demand and supply conditions. They expect the economist and the statistician to analyze current and prospective trends and to make useful projections indicating the probable direction of major changes in the future. With these needs in mind, the United States Department of Agriculture in the past has made and published several projections of the long-range demand for and supply of farm products. The present report brings up to date the Department's projections of potential demand for farm products around 1960 and 1975. While these projections show a substantial increase in total demand for farm products, they indicate some sharp differences in trends. For example, they point to sizable increases in the demand for livestock products and fruits and vegetables, and decidedly more limited increases for food grains and potatoes. Projections of demands and supplies are made on the basis of certain assumptions. We have assumed a stable price situation and a trend toward world peace. We have also made assumptions concerning such factors as population, labor force, employment, hours of work, and productivity. The projections shown in this report are not forecasts. Rather, they indicate what trends we would expect in the demand for farm products under a set of assumptions. The projections could go wrong if we suffered a long business depression, or if we became involved in a large-scale war, or if nutritional findings or consumer preferences brought changes in consumption patterns appreciably different from those indicated in this report.

Frederick V. Waugh

GROWTH IN DEMAND for farm products during the next quarter-century will depend primarily on growth in population and consumer income. Total requirements for farm products for domestic use and export under conditions of full employment are projected for 1975 to a level around 40 to 45 percent above 1953. Population growth of 30 to 35 percent would contribute most to this expansion in demand. If current consumption rates are assumed, requirements for farm products would rise about a third. But with an approximate doubling in the size of the economy and rising consumer incomes, per capita consumption of farm products may increase about a tenth from 1953 levels. The increase would reflect primarily a shift to higher unit-cost foods rather than consumption of more food.

Projected use of livestock products increases by about 33 percent if current consumption rates are assumed, and by more than 40 percent for the higher projected consumption rates. Increases for cattle, hogs, and poultry would be larger than for sheep, dairy products, and eggs. Food use of crops on the average may total around a third larger in 1975 than in 1953, with much of the increase in vegetables and fruits, especially citrus. Little increase in use of food grains and such crops as potatoes and dry beans is indicated.

The projected rise in requirements for feed concentrates and hay, for the two consumption levels assumed, range from about 25 percent to around 40 percent from 1953 to 1975. These gains reflect the rise in livestock production. Substantial increases in total use of such nonfood crops as cotton, tobacco, and some oils are in prospect. Most of the tabulations in this report were computed on the basis of a population of 210 million people by 1975. If the higher population assumption of 220 million people is used, projected utilization and needed output would be 5 percent higher.

Foreign markets could take relatively large quantities of our cotton, grains, tobacco, and fats and oils in coming years. The volume of agricultural exports projected for 1975 is about a sixth above 1952–53, and somewhat below the large volume exported during the 1955–56 fiscal year, when large export programs were in effect.

Different rates of growth in demand and trends in technological developments on the supply side will make supply increases more difficult for some commodities than others. Under the projected consumption rates, production of livestock products as a whole would need to increase more than 40 percent from 1953 to 1975—around 45 to 50 percent for meat animals and poultry products, nearly 30 percent for dairy products.

Output increases that would be needed to match projected requirements based on current consumption rates are in general smaller—possibly around 25 to 30 percent above 1953 for most types of livestock products. With crop output well in excess of requirements in 1952–53, an output increase from that base year of about a fourth would meet prospective expansion in utilization under projected consumption rates. A smaller output of food grains, and little increase in potatoes and beans, would be indicated for 1975. Sizable increases in production, however, are suggested for feed grains, many vegetable crops, and fruits.

Why and How Projections Were Made

Appraisals of long-run demand for agricultural products are of continuing interest to farmers, consumers, industries that sell to farmers, other industries, legislators, and the Government. It should be realized that such projections are not forecasts. They are based on specific assumptions as to growth in population, labor force, and levels of consumer income. The major assumptions on which these projections are based are as follows:

1. Population will increase to 210–220 million people by 1975.

2. Labor force and employment will grow commensurately with the growth in population. A high-employment economy is assumed with unemployment averaging around 4 to 5 percent of the labor force.

3. A trend toward world peace is assumed, with the proportion of the Nation's output devoted to national defense becoming smaller.

4. Productivity of the labor force will grow much as in the past. Even with fewer hours of work per week, real income per capita for the total population may increase by more than 50 percent.

5. Prices in general are assumed at 1953 levels both for agriculture and for the economy as a whole.

Projections of this kind are of value in looking ahead to the possible role of agriculture in the future. Despite the fact that such projections are bound by the assumptions under which they are made, they highlight the underlying trends that affect agriculture. Within this framework some indication of the problems that are likely to emerge in agriculture, the directions of the research needs, and the potential markets for farm products, can be appraised. This gives some basis for appraising what agriculture might be called upon to do in terms of the needs for food and fiber in a prosperous, growing economy.

In appraising long-term growth in demand we have no economic forecasting techniques that are highly accurate, or to which usual probability error limits can be applied. Long-run economic appraisals are not unconditional predictions of the future; they are at best projections made in a framework of assumptions. The nature of growth and change in the economy, over time, does not lend itself to the rigorous type of analysis used in short-period or static appraisals.

The long-run appraisal must be concerned not only with current relationships but with possible changes in these relationships over time. The influence of prices and incomes on consumption probably vary, over time, with changes in real income, popular changes in "taste," technological developments, nutritional findings, and changes in modes of living. Much of the increase in consumption of frozen food during recent years, for

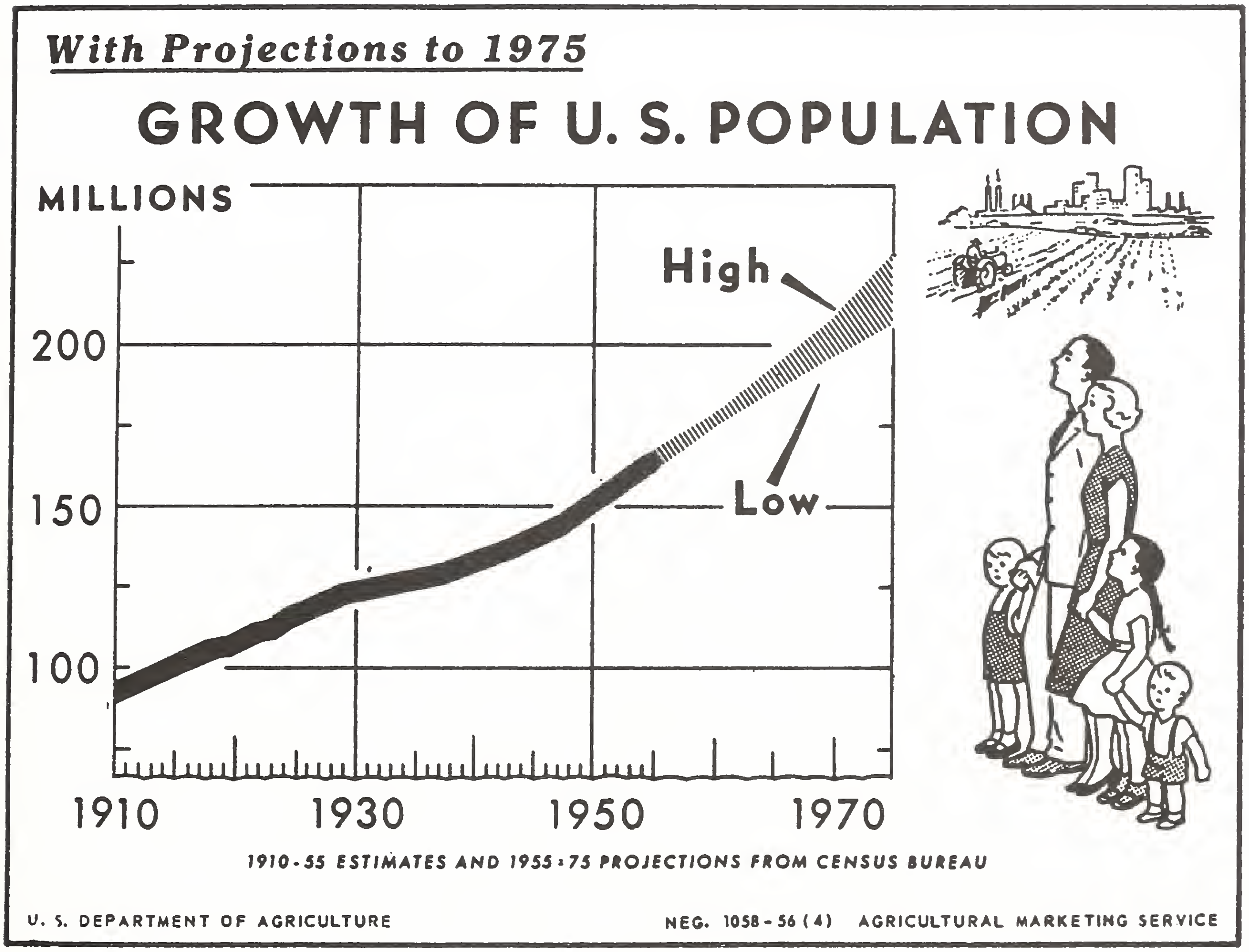

FIGURE 1.

example, can probably be attributed to factors other than changes in price and income. Likewise, some trends in per capita consumption of potatoes and cereals apparently reflect nutritional developments and changes in modes of living.

Methodology used for long-run appraisals must be largely historical insofar as past relationships and trends in economic, social, and political conditions provide a basis for appraising the future. Stability of rates of growth and the general inertia of consumer behavior patterns provide much of the foundation for an appraisal of prospective growth in demand for farm products during the next two or three decades. At best, refined statistical techniques must be supplemented by judgment. Despite the problems involved, projections of this type will be made as long as individuals are required to make decisions involving long-run commitments.

General Economic Framework

Expansion in demand for products of the farm depends primarily on population growth and the influence of consumer income and "taste" changes on the consumption of farm products. With rising real incomes, increased population tends to result in a corresponding expansion in demand for farm products. Rising incomes may not greatly expand total consumption but they will vary the rate of growth in demand for individual commodities.

Population Growth to Continue

Population in the United States in mid-1955 was estimated at more than 165 million people. Projections for 1975, prepared in 1955, range from 207 to 228 millions—somewhat above those made by the United States Bureau of the Census in 1953.

These projections range from about 30 to 43 percent above the base year 1953. Most calculations in this study assume a population increase of about 30 percent from 1953 to 210 million persons in 1975. However, some aggregates are adjusted to reflect a population increase of 36 percent to 220 million by 1975. These projections compare with a rise in population of 30 percent from 1929 to 1953 (fig. 1).

The shift of the rural population to urban areas and the downtrend in farm population are expected to continue during coming years. With growth in population there will be larger numbers in both the 10- to 20-year age groups and in the group 65 years and over. Regional shifts and different rates of growth are expected to result in rapid growth in population in the Pacific and Mountain States.

An Economy Twice As Large by 1975

The Nation's economy by 1975 may be nearly twice that of 1953, the base year for this study, if employment levels are well maintained. Growth of the economy will depend on expansion in demand and on potential output as determined by employment, hours worked, and output per manhour. Recent trends in productivity and prospective growth in the labor force indicate that a doubling in the gross national product in the next quarter-century is highly possible for an expanding peacetime economy.

Employment

A labor force of around 72 million workers by 1960 and around 90 to 95 by 1975 is indicated, on the basis of population growth and trends in labor-force participation rates by sex and major age groups. These trends reflect the tendency for more schooling in the lower age groups included in the labor force, for earlier retirement in the older age groups, and for a pronounced increase in the number of women who work.

In the projected framework a growing peacetime economy and a high level of employment are assumed. The length of the work week is expected to continue its long-run downtrend. An assumed unemployment rate of about 4 to 5 percent of the labor force does not rule out the probability of minor ups and downs in the economy in coming years. Depressions as severe as that of the 1930's are not considered likely.

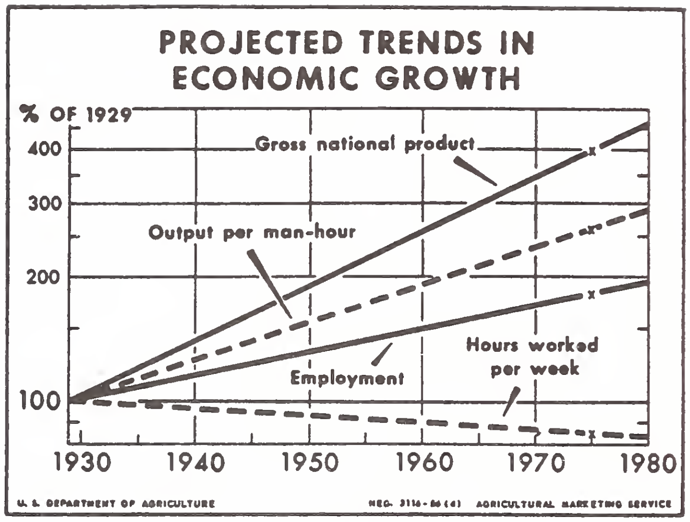

FIGURE 2.

Productivity and Output

Output per manhour for all workers, including those in Government and civilian services and in the Armed Forces, is projected to trend upward at a rate of about 2½ percent a year. The trend in output per manhour of work reflects not only the ability, training, and general efficiency of labor, but also the amount and efficiency of capital and other resources used in production. Although the projected rise is consistent with long-run trends, it may be conservative in view of the rapid growth in capital and recent developments in automation and possible new sources of power (fig. 2).

Output of goods and services under the employment and productivity assumptions indicated here would rise at the rate of about 3 to 3½ percent a year. The gross national product of the economy, after adjustment for price level change, doubled from 1929 to 1953, and it probably will at least double again by 1975. Real output of the economy could easily exceed projected levels, if demand increases continue to exert pressure on the economy as in recent years. But a somewhat higher level of total output and real income would not materially change the demand for farm products.

Consumer Income and Spending

A doubling of total output of the economy with the associated gain in employment would lead to an increase in per capita real income of around 60 percent between 1953 and 1975; the projected rise for 1960 is 10 to 15 percent. Such an increase in income will expand demand for all goods and services, including food, clothing, tobacco, and

other commodities made from farm products.

Government spending and revenue are expected to trend upward, but it is assumed that the Government will take a relatively smaller share of total output and income than in recent years. Investment outlays for new plant and equipment and residential building will rise with growth in the economy, possibly a little more rapidly than total output (table 1).

Demand for Farm Products

Total demand for farm products over time can be thought of as a relatively inelastic relationship between consumption and price—a relationship that shifts rather continuously in response to growth in population and real income. Thus the demand for farm products during the next quarter-century will depend to a large extent on population growth. Rising incomes, however, will contribute not only to an expanding total demand for farm products, but will influence the types of products that consumers want. Trends in popular consumption habits and technological developments also will influence changes in demand for farm products. Although foreign takings of farm products are small compared with total demand, the foreign market will continue to be important for such crops as wheat, rice, cotton, tobacco, and oils.

Population Growth a Major Demand Factor

Population growth during the next two or three decades may add 30 to 35 percent to total demand for farm products. This would be by far the most important contributor to growth in total demand for farm products. With rising incomes, population growth is assumed to add proportionately to the growth in demand for farm products. Some trends in the age composition and regional distribution of population may modify the effect of population on demand for farm products. But the uptrend in numbers of both younger and older persons, the decline in farm population, and regional shifts in population are not expected materially to influence total demand.

Rising Incomes and Consumption

Consumption of farm products as a whole is not very responsive to changes in either price or income; price and income elasticities are relatively

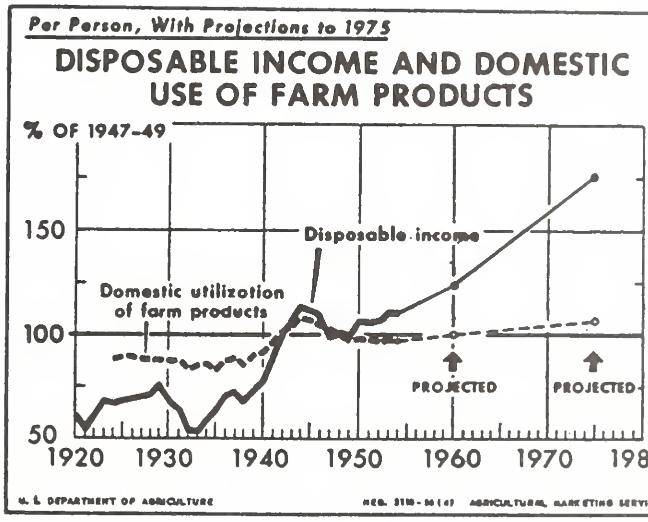

FIGURE 3.

small.[1] As a first approximation in this analysis, general price relationships existing in 1953 are assumed for the projections. Although this assumption temporarily rules out the effects of price change, such changes could have an important influence on consumption. The projected rise of around 60 percent in real income per person will probably result in a small increase in total per capita use of food and other farm products and will modify the pattern of consumption—the kinds of products desired (fig. 3).

Income effect on consumption.—Expenditures for food and other farm products tend to increase less, relative to income changes, than do expenditures for many nonfarm products.

Expenditures for food at retail stores and restaurants have increased during recent years about

[1] Income elasticity of consumption may be defined as the response of per capita use of a farm product to changes in per capita income. Suppose per capita consumption of a farm product is expressed in the following form:

$$q=kp^{a}y^{c} \qquad (1)$$

where (q) refers to quantity utilized per person, (p) to price per unit, and (y) to per capita real income. In terms of equation (1) income elasticity is represented by c and price elasticity by a.

This defines income elasticity as the relative change in quantity consumed divided by the relative change in income when other variables are held constant. For virtually all farm products, this relationship should be positive—consumption increases as real incomes rise. For some commodities, however, income elasticity is negative and consumers tend to use less of these products as their incomes rise. Price elasticity represents the relative change in quantity consumed divided by relative change in prices when other variables are held constant. The relationship is negative.

in proportion to income. This implies an elasticity of food expenditures with respect to income of around 1.0. But these expenditures include many services of processing and distribution. Expenditures for "eating out" or "TV dinners," for example, are very responsive to changes in income, but they may have little effect on total consumption of farm products. Bulk processing of food, furthermore, may result in less waste than comes from home preparation.

Demand for services is estimated to be around 5 times as responsive to changes in income as the demand for farm products. Empirical estimates based on a recent study [2] show an elasticity of outlays for marketing and processing (real terms) relative to real income of more than 0.7. The income elasticity of deflated farm value (an approximation of quantity) is only 0.15. The flexibility of retail expenditures (in real terms) relative to income, a weighted average of these elasticities, is about 0.4.[3] Weights are approximated on the basis of the farm share and the margin. The very low income elasticity of demand for farm products at the farm level will result in a long-run decline in the farmers' share. As this would give progressively less weight to the lower income elasticity, some change over time is implied for income elasticities at retail or for the marketing margin.

Changes in consumption are much less responsive to changes in income than are retail expenditures for farm products. For example, pounds of food consumed per person increased some during World War II, but they have not changed much during the last two or three decades. Consumer-purchase studies, based on a cross section of families, indicate that quantities of food consumed per person increase very little as incomes rise. Projected per capita use of food in pounds is about the same as the 1947–49 average.

Most indexes of food use per person are price-weighted to reflect up-grading of the diet as consumption shifts to livestock products and foods of higher cost. Analyses based on the Agricultural Marketing Service Index of Per Capita Food Consumption indicate an income elasticity of 0.2 to 0.25.[4] That is, an increase of 10 percent in real income per person is associated with an increase of 2 to 2½ percent in per capita use of food when prices are unchanged. But since the AMS index reflects some processing and marketing services, the elasticity may be higher than it would be at the farm level.

Moreover, some evidence suggests that income elasticities tend to decline at the higher income levels and may decline as incomes rise over time. Available statistical data show that income elasticities for most major farm products are somewhat smaller at the higher than at the lower levels of income. Estimates of per capita consumption of food in one study show an elasticity relative to income of 0.3 for consumer unit income levels $750 to $1,250 and an elasticity of about 0.15 for income groups $2,500 to $4,000.[5] It appears reasonable to expect that, as families move from lower to higher income levels, their consumption patterns reflect

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[2] These analyses are based on estimates of food expenditures, the marketing margin, and the farm value developed in *Changes In Food Expenditures, 1929 to 1954*, a manuscript by Marguerite C. Burk.

[3] Value at retail is the sum of value at the farm and costs of processing and marketing as follows:

$$V_r = V_f + V_m$$

and

$$V_r = a + bI, b = \frac{dV_r}{dI}$$

$$V_f = a_1 + b_1 I, b_1 = \frac{dV_f}{dI}$$

$$V_m = a_2 + b_2 I, b_2 = \frac{dV_m}{dI}$$

then,

$$V_r = a_1 + a_2 + b_1 I + b_2 I \text{ and}$$

$$\frac{dV_r}{dI} = \frac{dV_f}{dI} + \frac{dV_m}{dI}$$

The elasticity is,

$$\frac{dV_r}{dI} \cdot \frac{I}{V_r} = \frac{\frac{dV_f}{dI} \cdot I + \frac{dV_m}{dI} \cdot I}{V_f + V_m}$$

and

$$\frac{dV_r}{dI} \cdot \frac{I}{V_r} = \frac{\left[\frac{dV_f}{dI} \cdot \frac{I}{V_f}\right] V_f + \left[\frac{dV_m}{dI} \cdot \frac{I}{V_m}\right] V_m}{V_f + V_m}$$

[4] See Girshick, M. A., and Haavelmo, T., STATISTICAL ANALYSIS OF THE DEMAND FOR FOOD, Cowles Commission Papers, New Series, No. 24, 1947, p. 109; Tintner, G., MULTIPLE REGRESSION FOR SYSTEMS OF EQUATIONS, Econometrica, 14: 34–36. 1946. Burk, Marguerite C., CHANGES IN THE DEMAND FOR FOOD FROM 1941 TO 1950, Journ. Farm Econ. 33: 281–98. 1951. Working, Elmer J., APPRAISING THE DEMAND FOR AMERICAN AGRICULTURAL OUTPUT DURING REARMAMENT, Journ. Farm Econ. 34: 209–15. 1952.

[5] CONSUMPTION OF FOOD IN THE UNITED STATES, 1909 TO 1948. U. S. Dept. Agr. Misc. Pub. No. 691, 1949. Page 142.

TABLE 1.—*Income, output, employment, and price level 1929, 1951–53, 1953, and projections for 1960 and 1975*

Item	Unit	1929	Average 1951–53	1953	Projection		
					1960 [1]	1975	1975 [2]
Gross national product	Bil. dol	104.4	346.0	364.5	430	705	740
Personal consumption expenditures for goods and services.	Bil. dol	79.0	219.1	230.6	284	476	500
Per capita	Dol	640	1,376	1,424	1,590	2,272	2,272
Personal disposable income	Bil. dol	83.1	237.7	250.4	308	513	540
Per capita	Dol	673	1,493	1,547	1,725	2,449	2,449
Consumer price index	1947–49=100	73.3	113.0	114.4	114.4	114.4	114.4
Wholesale prices, all commodities	1947–49=100	61.9	112.2	110.1	110	110	110
Population [3]	Mil	123.5	159.2	161.9	178.6	209.5	220.0
Labor force [4]	Mil	49.4	66.6	67.4	72	91	95.5
Employment, including military	Mil	47.9	64.9	65.7	68.5	86.5	91.0
Unemployment	Mil	1.6	1.7	1.6	3.5	4.5	4.5
Prices received by farmers	1910–14=100	148	283	258	258	258	258
Prices paid, interest, taxes and wage rates	1910–14=100	160	283	279	279	279	279
Parity ratio	1910–14=100	92	100	92	92	92	92

[1] The higher population of about 180 million in 1960 would raise the gross national product by around 5 billion dollars
[2] Assuming population of 220 million for 1975.
[3] Total population of continental United States as of July 1, including Armed Forces overseas, adjusted for underenumeration.
[4] Includes Armed Forces. Figures may not add to total, because of rounding.

some of the consumer behavior observed for higher income families. Assuming no change in the general price level or the relative income position of families, projected incomes for 1975 would put more than two-thirds of all families in income levels above $5,000. This compares with about 45 percent in 1950.

Income effect on kinds of goods consumed.—Although rising income may effect a relatively small increase in total use of food per person, it will influence the kinds of products consumers want. The nature and direction of these changes under given price assumptions are suggested by elasticities which approximate empirically the relationship of consumption to income.

Livestock Products.—Livestock products in general show more response to changes in income and price than do most crops. Consumption of beef and veal in a given framework of prices is more responsive than pork to changes in income. Consumption of chicken and turkey also is fairly responsive to changes in income. Dairy products in total apparently respond little to income change, and fats and oils in total show almost no response. Of course, there are many influences other than price and income which determine trends in consumption. For example, per capita use of lamb and veal will depend to a considerable extent on demand for dairy products and wool. Likewise supplies of chicken available are partly a function of the demand for eggs. In addition, for some commodities there are trends in popular consumption habits that appear to be largely independent of economic considerations (table 2).

Major crops.—A major part of the demand for crops is derived directly from the demand for livestock products as reflected in use of feed. In most years around 40 to 50 percent of total crop production is used for feed; food use may range from 25 to 30 percent; the remainder, in order of importance, goes into nonfood use, exports, and seed.

Feed supplies come primarily from the four major feed grains (corn, oats, barley, and grain sorghums) and from hay and pasture. But some wheat, rye, and several other crops are used for feed. Mill byproduct feeds, oilseed cake and meal, and animal proteins also provide an important part of the supplies of feed concentrates.

For feeds that are essentially a byproduct, supplies are determined largely by projected demand for major uses; cottonseed meal production, for example, will depend on output of cotton; mill feeds on quantities of grains milled. Supplies of

Table 2.—*Income elasticities assumed as a basis for projecting per capita consumption of major farm products* [1]

Major crops	Income elasticity	Major livestock products	Income elasticity
Vegetables (farm weight equivalent)		Meat	0.25
Tomatoes	0.40	Beef	.40
Leafy, green and yellow [2]	.25	Veal	([3])
Other vegetables [4]	.20	Lamb	([3])
All vegetables	.25	Pork	.20
Melons and cantaloups [5]	—.40	Poultry products	
Potatoes and sweetpotatoes	—.25	Chicken and turkey	.30
Fruits		Eggs	.15
Apples	([6])	Dairy products	
Citrus	.65	Total milk equivalent	.10
Other [7]	.13	Fluid milk and cream	.12
All fruit	.32	Fats and oils	.06
Other food crops			
Wheat and flour	—.20		
Dry beans and peas	—.20		
Sugar	—.07		

[1] These elasticities were assumed on the basis of statistical evidence, trend influences, and judgments relating to other factors. Thus some elasticities are implied by projected consumption.

[2] This group includes cabbage, a major vegetable, which in the 1948 consumer purchase survey showed a negative income elasticity of about −0.2 and possibly some trend in per capita consumption.

[3] Per capita use of veal and lamb was determined by output of the dairy and sheep industry which was dependent on other factors.

[4] The "other group" contains onions, a major vegetable, and the 1948 study shows a negative elasticity of nearly −0.3.

[5] A gradual downtrend in consumption was assumed.

[6] Apples may show some positive income effect but a slight downtrend in consumption.

[7] May depend largely on composition and proportion used as fresh, canned, or frozen.

byproduct feeds and projected total demand for feed based on livestock production, fix the requirements for major feed grains.

Although combined use of crops for food tends to change little in response to changes in income, per capita use of most vegetables and fruits, especially citrus, is fairly responsive to income changes. But per capita use of potatoes and sweetpotatoes, cereals, dry beans, and some vegetables, have tended to decline as incomes rise. Exact measurement of these tendencies—income elasticities—is more difficult than for livestock products, yet they can be approximated from available studies.

Empirical approximations of these income elasticities, based on consumer-purchase surveys, time-series analyses,[6] and judgment of commodity specialists, were used as a basis for projecting demand for individual farm products. These are summarized in table 2. In some instances, elasticities are implied by an independent projection of per capita consumption.

Consumption per Person

With a rise in real consumer income per person of about 60 percent from 1953 to 1975, and with no change in relative prices, what do the income elasticities imply for per capita consumption of farm products in total, and for major commodities?

Food consumption per person, as indicated by the Agricultural Marketing Service Index, would be expected to increase about 12 percent on the basis of the projected rise in income and an income elasticity of about 0.2. This would increase the index to around 113 percent (1947–49=100) by 1975.

Independent projections for individual commodities summarized in the AMS Index also push the total up about 12 percent by 1975, and 3 percent by 1960. Consumption increases reflect the continued shift to higher unit-cost foods and away

[6] See for example Fox, Karl A., factors affecting farm income, farm prices, and food consumption. Agricultural Economic Research, 3: 65–82, 1951. Nordin, J. A., Judge, G. C., and Wahby, O., application of econometric procedures to the demands for agricultural products. Iowa State College Research Bul. No. 410. 1954. Rojko, Anthony S., an application of the use of economic models to the dairy industry, Journ. Farm Econ. 35: 834 ff. 1953.

from cereals and potatoes. In the projected diet, the pounds of food and calories consumed per person are changed only a little. Increases in proteins, minerals, and other requirements for an improved diet are provided.

As the Agricultural Marketing Service Index of Per Capita Consumption reflects some processing and marketing services, projected requirements were expressed at the farm level, and an index was constructed using prices received by farmers as weights. Requirements are worked back to the farm level by expressing, for example, meats in liveweight of meat animals and fruits and vegetables on a fresh farm-weight equivalent basis. This index would reflect the shift to higher unit-value foods at the farm level but not, for example, the shift to frozen and processed food. Projected per capita consumption of farm products summarized in this index increases nearly 10 percent from 1953 to 1975, about 2 percent by 1960.

A comparison of per capita consumption indexes for major groups of farm products suggests a tendency for the AMS retail price weighted consumption index to increase somewhat more, relative to income, than the increase at the farm level. For most livestock products, results for the two indexes appear consistent and only moderately different. In both, the increase in per capita consumption of livestock products is about a tenth from 1953 to 1975. Comparisons were somewhat more difficult to make for major crops. The same tendency for a smaller gain in the consumption index at the farm level was observed. Differences are sizable for grains and fruits which require considerable marketing and processing services.

Livestock products.—Per capita consumption of meats is projected to around 173 pounds by 1975 from 154 pounds in 1953. This increase reflects the rise in real income and its effect on consumption, as well as possible restrictions on the supply of veal and lamb. The gain of around 20 pounds in total meat consumption per person is about the same as the increase from 1925–29 to 1953. In the case of cattle and calves, prices were considered relatively low and consumption correspondingly high in 1953, the base year. Also, hog prices were relatively high and consumption low in 1953.

In appraising consumption prospects for 1975, prices of cattle are assumed about 12 percent higher and hog prices nearly a fifth lower than in 1953. Projected demand for dairy products indicates little change in per capita consumption of veal. Thus combined use of beef and veal is less than a tenth above the relatively large consumption per person in 1953. On the other hand, per capita consumption of pork projected for 1975 is nearly a fifth above the relatively small consumption in 1953. Consumption of lamb per person reflects primarily expected growth in the sheep industry.

Per capita consumption of dairy products in 1953 totaled 682 pounds (milk equivalent, fat-solids basis) compared with 798 pounds average for 1925–29. The decline of the last two to three decades was due to a drop of around one-half in per capita use of butter. Combined per capita demand for milk products is expected to increase slowly in response to the projected rise in income. Total milk consumption per person is projected to around 720 pounds (milk equivalent) for 1975. Most of the increase is in consumption of fluid milk. Butter consumption is held at about the 1954 level. Use of milk and butterfat in ice cream has held relatively steady in recent years but may decline some if use of vegetable fats becomes more widespread (table 3).

Consumption of chicken and turkey per person in 1953 totaled about 27 pounds (eviscerated weight), an increase of about 50 percent from the 1925–29 average. The projection for 1975 is almost a fifth above 1953. Egg consumption is projected to more than 400 eggs per person, an increase of nearly 8 percent from 1953; the increase from the 1925–29 average to 1953 was more than a fifth. The big increase in consumption of poultry products since 1925–29 reflects substantially lower prices relative to livestock products as a whole, and relative to all farm products. Technological developments in feeding and production of poultry products have been rapid in the last two or three decades.

Per capita consumption of food oils is not expected to change much during the next quarter-century. In 1953, consumption of food fats and oils totaled 43.5 pounds (fat content). This compares with an average of around 43 pounds in 1925–29. Stability in the total reflects a downtrend in consumption of butter and an uptrend in margarine. Consumption of oils in lard and shortening has changed little, but in salad oils and

TABLE 3.—*Per capita consumption of major livestock products, selected periods 1925 to 1955 and projections for 1960 and 1975*

Commodity	1925–29	1951–53	1953	1955	Projections	
					1960	1975
Meat (carcass weight):	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Beef	53.8	64.5	76.7	81.2	74.0	85.0
Veal	7.3	7.7	9.5	9.4	9.5	9.0
Lamb and mutton	5.3	4.0	4.6	4.6	4.5	4.0
Pork (excluding lard)	66.9	68.4	62.9	66.0	68.0	75.0
Total	133.3	144.6	153.7	161.2	156.0	173.0
Poultry and eggs:						
Chicken (eviscerated wt.)	14.3	22.6	22.6	20.9	24.0	27.0
Turkey (eviscerated wt.)	n. a.	4.4	4.5	5.0	4.5	5.2
Total (eviscerated wt.)	n. a.	27.0	27.1	25.9	28.5	32.2
Eggs (number)	330	382	374	366	380	403
Dairy Products:						
Total milk (fat solids basis)	798	693	682	700	698	720
Cheese	4.5	7.3	7.3	7.7	7.5	8.0
Ice cream (net milk used)	24.1	46.0	47.6	48.4	45.0	40.0
Fluid milk, cream, condensed and evaporated milk, milk equivalent	364	389	385	387	395	415
Fats and Oils: Food (fat content)	n. a.	42.9	43.5	45.0	44.7	45.5

dressings, and in ice cream, it has increased materially during the last few years. Per capita use of oils is projected to 45.5 pounds for 1975, close to current consumption rates. In general, past trends in use of oils are expected to continue in the coming years (fig. 4).

Crops.—Consumption of fruit per person may increase nearly a fifth from 1953 to 1975. As indicated by the elasticities assumed, the increase would be greatest for citrus fruits—possibly more than a third. The projection of 27 pounds of commercial apples for 1975 compares with a per capita consumption (both commercial and noncommercial) of about 49 pounds for the 1925–29 average. On the other hand, per capita consumption of citrus more than doubled from 1929 to 1953. This large increase was due to much lower prices for citrus relative to other fruit, to innovations in processing, and to the gain in income. Consumption of other fruits in 1953 was down to 88.5 pounds from 98.9 pounds in 1925–29.

Vegetable consumption per person (excluding potatoes) is projected for 1975 to about a sixth above 1953. This compares with a gain in consumption of 38 percent from 1925–29 to 1953 due in part to lower relative prices for truck crops. The largest relative gain in per capita use of vegetables is projected for tomatoes, although consumption of most leafy, green, and yellow vegetables may increase as much or more than tomatoes. The leafy, green, and yellow group contains cabbage, and the "other vegetable" group contains onions. Per capita consumption of both these major vegetables probably will decline as real incomes rise (table 4).

Consumption of potatoes, dry beans and peas, and grain products is projected to continue their downtrend during the next two to three decades. Consumption of potatoes in 1925–29 averaged 144 pounds per person and by 1953 was down to 102 pounds. The projected decline to 1975 is expected to be somewhat less rapid; an expansion in such uses as potato chips and frozen french fries may moderate the downtrend in consumption. The grain equivalent of wheat and flour consumption in 1953 totaled 179 pounds per person compared with an average of 254 pounds in 1925–29. A continued, but somewhat slower, decline in consumption of wheat is projected for the next two decades.

Nonfood Use of Farm Products

Nonfood use of such commodities as cotton, wool, tobacco, some oils, and grains for industrial uses probably total, in most years, around 12 to 14 percent of farm production. Combined per

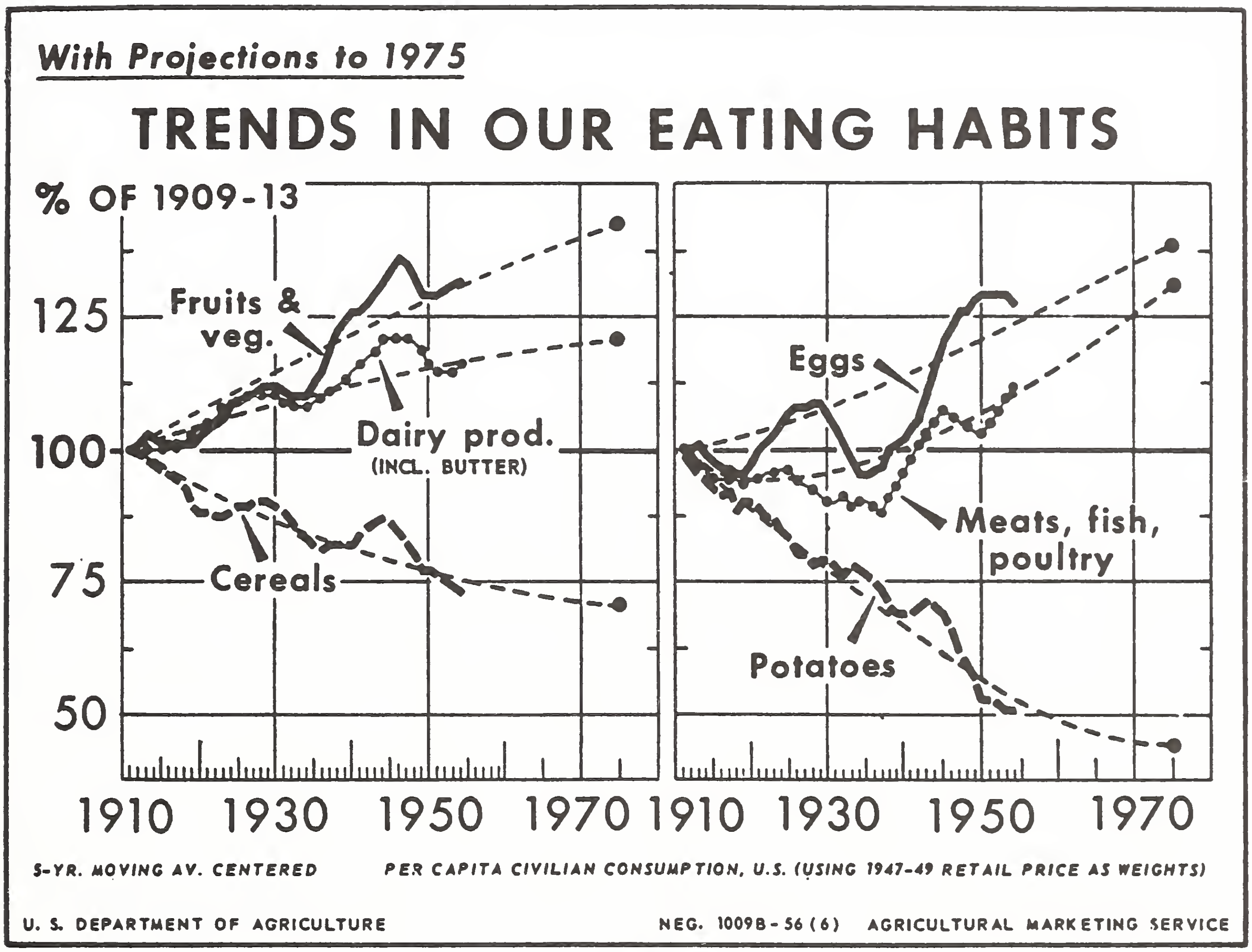


FIGURE 4.

capita use of these nonfood products is projected to rise around 8 percent from 1953 to 1975.

Demand for cotton is derived primarily from the demand for clothing, household furnishings, and industrial uses. Thus the level of income and economic activity is an influential determinant of per capita use of cotton. In recent decades, however, use of cotton per person has shown no pronounced upward trend. The same is true for wool although there have been sizable variations from periods of widespread unemployment to periods of swollen wartime demands. But use of synthetic fibers has expanded rapidly in recent decades, making substantial inroads in the market for natural fibers.

Although synthetic fibers will continue to compete with cotton and wool, with the substantial rise in consumer income an increase in per capita use of cotton is projected for 1975. Consumption of wool per person is held at about 1.8 pounds, somewhat below per capita use in 1953 but about at the current rate of use per person (table 5).

Use of tobacco per person has trended strongly upward during recent decades. With a substantial rise in income in prospect, a continued increase is projected for the next two or three decades. But recurrent publicity on possible adverse effects of smoking may moderate the uptrend in per capita use of tobacco.

Major nonfood uses of fats and oils are in the manufacture of such products as soap, paints, varnishes, linoleum, greases, and industrial products. Demand for these products in general tends to be relatively elastic. But the value of the raw materials used generally represents a small part of the final product cost. Moreover, in recent years

TABLE 4.—*Per capita consumption of major food crops, selected periods 1925 to 1955 and projections for 1960 and 1975*

Commodity	1925–29	1951–53	1953	1955	Projections 1960	Projections 1975
Fruits (farm weight equivalent):	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Apples (excluding noncommercial)	n. a.	28. 0	25. 7	26. 3	30. 0	27. 0
Citrus	32. 4	83. 1	84. 3	88. 6	92. 0	115. 0
Other	98. 9	86. 9	88. 5	84. 2	93. 0	95. 0
Total	180. 3	198. 0	198. 5	199. 1	215. 0	237. 0
Vegetables (farm weight equivalent):						
Tomatoes	31. 4	53. 1	53. 1	54. 3	55. 0	65. 0
Leafy, green and yellow	65. 3	82. 4	82. 5	80. 7	85. 0	95. 0
Other	52. 9	71. 2	71. 7	72. 1	74. 0	80. 0
Total	149. 6	206. 7	207. 3	207. 1	214. 0	240. 0
Potatoes and sweetpotatoes:						
Potatoes	144. 0	102. 0	102. 0	101. 0	98. 0	85. 0
Sweetpotatoes	21. 1	7. 4	8. 0	9. 0	9. 0	9. 0
Dry beans and peas (clean basis)	8. 4	8. 4	8. 2	8. 2	8. 0	7. 0
Grain products (grain equivalent):						
Wheat	254. 0	186. 0	179. 0	172. 0	175. 0	160. 0
Rye	3. 6	1. 9	1. 8	1. 7	1. 5	1. 5
Rice	5. 6	5. 4	5. 3	5. 3	5. 5	5. 5
Corn	n. a.	49. 4	48. 2	47. 3	47. 0	45. 0
Oats	n. a.	6. 9	6. 9	6. 8	6. 5	6. 5
Barley	n. a.	1. 8	1. 8	1. 8	1. 8	1. 8
Sugar, cane and beet	101. 0	95. 3	96. 5	96. 3	95. 0	93. 0

TABLE 5.—*Per capita nonfood use of major farm products, selected periods 1925 to 1955 and projections for 1960 and 1975*

Commodity	1925–29	1947–49	1951–53	1953	1955	Projection 1960	Projection 1975
Nonfood fats and oils:	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Soap	n. a.	13. 6	8. 8	8. 1	6. 7	6. 5	4. 0
Drying oil	n. a.	6. 6	6. 3	6. 1	6. 3	6. 0	5. 0
Other industrial	n. a.	4. 9	6. 8	7. 0	7. 1	8. 5	11. 5
Total	n. a.	25. 1	21. 9	21. 2	20. 1	21. 0	20. 5
Cotton	27. 7	29. 5	29. 3	27. 9	26. 5	30. 0	32. 0
Wool, apparel	2. 1	3. 1	2. 3	2. 2	1. 7	1. 8	1. 8
Tobacco [1]	9. 0	12. 0	12. 8	12. 9	12. 2	13. 8	15. 4

[1] Unstemmed processing weight, per person 15 years and over including Armed Forces overseas.

synthetic detergents have taken over a large part of the market for soap manufactured from fats and oils.

Recent technological developments in the chemistry of the manufacture of paint and varnish have resulted in the use of more synthetic resins and rubber. Although these trends may continue, technological developments probably will expand other uses of industrial oils. Therefore little change is projected in total nonfood use of fats and oils. Industrial uses of grains are expected to expand as population and the economy grow.

Foreign Demand

The foreign market for United States farm products depends on a complex of forces, many of which are noneconomic in nature and difficult to appraise. World demand for food and fiber will increase, and world markets probably will continue in coming years to take relatively large quantities of our production of cotton, grains, tobacco, and fats and oils.

World population is expected to increase around 40 to 45 percent from 1950 to 1975 with larger than average gains in India and in countries of the Far East, Latin America, and the Middle East. Increases somewhat smaller than average are in prospect in Western Europe, Oceania, Japan, and Africa.

Population growth alone does not assure a corresponding increase in demand. But with consumer income and the level of living generally expected to rise, demand for food should increase more rapidly than growth in population.

Estimates based on income growth for major world areas and rough measures of income elasticity of demand for food were compared with estimates based on Food and Agriculture Organization targets for improved diets. These data suggest a world demand in 1975 some 50 to 65 percent above 1950. Larger than average gains are indicated for such areas as India, Communist China and Asian satellites, Latin America, the Middle East, and non-communist Far East (excluding Japan).

Rising incomes will lead to changes in the pattern of consumption in favor of more nutritive and protective foods. These changes can be only roughly appraised, but per capita demand for meat, dairy products, fruit, vegetables, and pulses (beans, peas, lentils) are likely to increase much more rapidly than the demand for cereals, starchy roots, and sugar. It appears probable that, with existing technology and readily accessible new lands, foreign agricultural production could be increased rapidly enough to meet a large part of projected needs in most areas of the world. Further, the trend toward self-sufficiency in the production of food and fiber will continue in most foreign countries, or groups of related countries, for reasons of politics and security.

World markets are expected to take relatively large quantities of our cotton, grain, tobacco, and fats and oils. The volume of agricultural exports projected for 1975 is about a sixth above the relatively small exports in 1952–53 and somewhat below the large volume exported during the 1955–56 fiscal year, when large export programs were in effect. The projected increase for fats and oils from 1952–53 to 1975 looks large but the big exports of fats and oils in the 1954–55 marketing year are close to levels projected for 1975 (table 6).

Agricultural exports in 1952–53 approximated less than a tenth of total output. Foreign takings are expected to continue to be a relatively small proportion of the total demand for farm products.

TABLE 6.—*Exports and shipments of major agricultural products, average 1947–49, 1952–53 and projection for 1960 and 1975*

Commodity	Crop year begining	Unit	1947–49	1952–53	Projection 1960	Projection 1975
Wheat, including flour and products	July 1	Mil. bu	433. 6	321. 6	250	275
Corn	Oct. 1	do	74. 8	139. 6	125	150
Cotton	Aug. 1	Mil. bales	4. 2	3. 0	[1] 4. 0	[1] 4. 5
Nonfood fats and oils	Oct. 1	Mil. lb	[2] 308	1, 169	1, 265	1, 620
Food fats and oils	do	do	[2] 945	1, 078	1, 369	2, 587
Tobacco	July–Oct.[3]	do	540	570	620	670
Total volume of exports	(2)	1947–49=100	100	86	85	101
Total volume of imports	(2) (4)	1947–49=100	100	112	117	140

[1] Assumes United States export prices will be substantially competitive with foreign prices.
[2] Computed from supply and disposition index made for this study.
[3] July for flue-cured and cigar wrapper. October for all other types. Tobacco exports include leaf equivalent of manufactured tobacco products exported.
[4] Volume of imports would be approximately comparable to the index of volume of supplementary or similar competing agricultural products grown in the United States.

Imports.—Imports of agricultural products are expected to rise with the growth in population and in economic activity. Imports of products similar to those produced in the United States, usually designated as supplementary, are projected for 1975 at about a fourth above 1953, and for 1960 possibly 4 or 5 percent higher. Imports of complementary products such as rubber, coffee, raw silk, cocoa beans, carpet wool, bananas, tea, and spices, probably will rise relatively more. Total consumption of these products, which is fairly responsive to rising incomes as well as to population growth, may well increase 50 percent or more from 1953 to 1975.

Projected Total Requirements

Population growth and domestic use per person, together with foreign takings, will determine total requirements for farm products. In this study, appraisals were made in some detail for two levels of consumption. The lower projection of requirements is based on approximately current rates of consumption. This assumes a situation in which the economy fails to grow as rapidly as expected, with conditions unfavorable enough to hold per capita consumption at about current (1955) levels. Exports were assumed at 1953 rates for the lower level of requirements.

The higher requirements are based on a projection of per capita consumption which reflects an increase of about 60 percent in income per person and trends in popular consumption habits. A population of 210 million was assumed for 1975, an increase of about 30 percent from 1953; the increase by 1960 may be around a tenth from 1953. This growth in population is conservative, especially the projection for 1975. Recent higher population projections suggest the possibility of about 220 million people by 1975. This assumption of a 5-percent larger population would add proportionately to projected requirements for farm products. Projected utilization shown in figure 5 is based on the higher projected consumption rates with the population for 1975 ranging from 210 to 220 million (fig. 5).

Requirements for farm products projected for 1975 on the basis of current consumption rates, which are only a little above 1953 base levels, reflect primarily population growth. On this basis, total utilization for 1975 would be nearly a third above 1953 with the increase for livestock products slightly in excess of that for crops.

TABLE 7.—*Utilization of major livestock products, 1953 and alternative projections for 1960 and 1975* [1]

[1953=100]

Commodity	1953	Projection 1960		Projection 1975	
		I [2]	II [3]	I [2]	II [3]
Meat animals:					
Cattle and calves	100	109	105	127	138
Pork (excluding lard)	100	113	118	132	152
Sheep and lambs	100	111	108	130	113
Total	100	110	110	129	143
Dairy products, total:					
Milk (fat solid basis)	100	113	111	131	134
Poultry products:					
Eggs	100	108	112	126	140
Chicken and turkey	100	105	115	123	153

[1] Utilization includes domestic use (food and nonfood) and exports.

[2] Level I assumes approximately current consumption rates per person for both 1960 and 1975.

[3] Level II is based on a projection of per capita consumption reflecting the effects of an increase in real per capita income—about 60 percent from 1953 to 1975—and trends in popular consumption habits.

Requirements would increase by around 40 percent from 1953 to 1975 on the basis of the projected higher consumption levels. Requirements for livestock products increase by more than 40 percent while the gain for crops would be around 36 percent.

Livestock products.—Projected requirements for meat animals increase by nearly 30 percent from 1953 to 1975 under the lower consumption rate, and increase by nearly 45 percent under the higher. The increase by 1960 is about a tenth above 1953 under both assumptions. Projected increases for pork from the relatively low levels in 1953 are generally larger than those for beef and lamb. Requirements projected for poultry products both in 1960 and 1975 are considerably smaller for current consumption rates than for the higher projected consumption rate. Requirements projected for dairy products are not materially different for current and projected consumption rates (table 7).

Assuming little change in average weight of animals and about average death loss and calf crop, projected requirements for the higher consumption rates point to around 125 million head of cattle on farms by 1975. There were 94 million

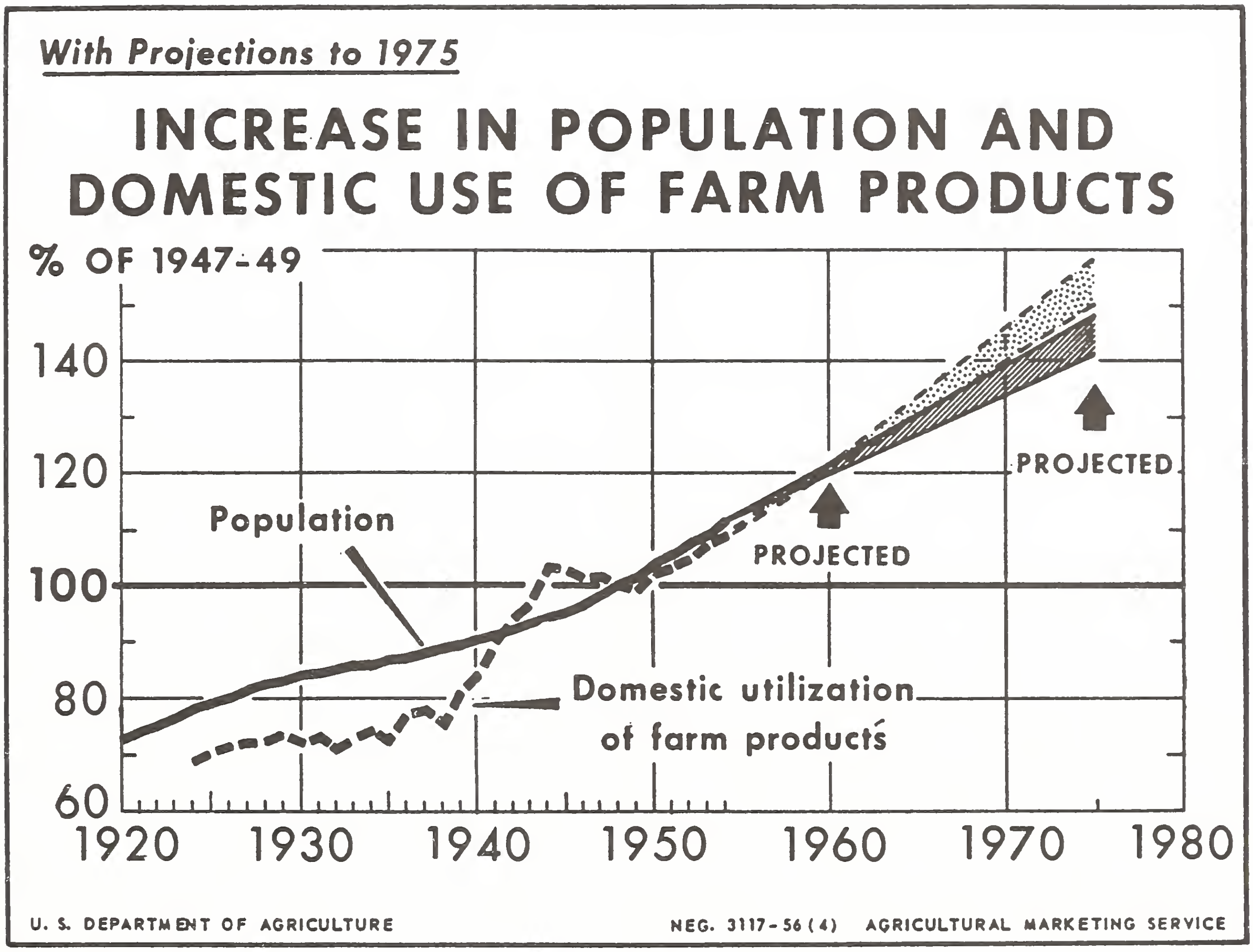


FIGURE 5.

head on January 1, 1953 and 96½ million in 1955. With a continued rise in milk output per cow, the required increase in number of cows milked may be small. The pig crop under the higher consumption rate would increase to around 130 million head from about 78 million in 1953 and 95 million in 1955. Sheep numbers increase to about 33 million stock sheep from 27.6 million in 1953 and 27 million in 1955. Chickens raised would increase under the higher consumption rates by more than a sixth, broilers by possibly 80 percent, and turkeys by around 50 percent from 1953 levels to meet expanded requirements in 1975. A larger population would require proportionately more livestock products.

Crops.—Use of crops is projected under the higher consumption rates to rise by about 36 percent from 1953 to 1975 and by more than a tenth by 1960. If approximately current consumption rates are assumed, projected use of crops increases from 1953 by about a tenth for 1960 and by about 30 percent by 1975. Variation in requirements for individual crops and groups of crops, however, is considerable.

Projected requirements for food grains and potatoes in general would change little from 1953. The assumption of current rates of consumption increases the requirements for these crops from 1953 to 1975 by more than would be true if projected consumption rates were used as a basis for calculating total requirements. This is because per capita consumption of cereals and potatoes in the projected consumption rates, trends downward rather than being assumed at current rates.

Larger requirements by 1975 were projected for vegetables, citrus fruits, feed concentrates, fats and

TABLE 8.—*Utilization of major crops, 1953 and projections for 1960 and 1975* [1]

[1953=100]

Commodity	1952–53	Projection 1960		Projection 1975	
		I [2]	II [3]	I [2]	II [3]
Food grains:					
Wheat	100	94	95	108	104
Rice	100	104	92	109	95
Fruits, fresh weight equivalent: [4]					
Apples	100	104	120	123	128
Citrus	100	117	122	135	176
Other	100	104	111	121	132
Vegetables, farm weight equivalent: [4]					
Tomatoes	100	112	113	130	154
Leafy, green and yellow	100	105	111	123	145
Other	100	105	110	123	138
Potatoes [4]	100	105	103	120	106
Dry, edible beans [4]	100	108	96	122	98
Sugar, raw [4]	100	111	110	130	126
Food fats and oils	100	113	115	130	148
Nonfood fats and oils	100	104	110	119	131
Feed concentrates	100	109	114	125	142
Cotton	100	107	118	116	143
Wool	100	85	90	99	105
Tobacco	100	107	117	129	155

[1] Utilization includes domestic use (food and nonfood) and exports.

[2] Level I assumes approximately current consumption rates per person for both 1960 and 1975.

[3] Level II is based on a projection of per capita consumption reflecting the effects of an increase in real per capita income—about 60 percent from 1953 to 1975—and trends in popular consumption habits.

[4] Calendar year 1953 is base year.

oils, cotton and tobacco. The gains, however, assuming current consumption rates, reflect primarily the growth in population and are smaller than requirements based on projected consumption rates (table 8).

Under the higher consumption rates, requirements for feed concentrates and hay are up about 40 percent from 1953 to 1975. This expansion may call for an increase of 40 to 45 percent for the major feed grains—corn, oats, barley and sorghum grains. It should be pointed out, in this connection, that feed requirements assume feeding rates per livestock production unit around 1951–53 levels. If there are extensive new efficiencies in feeding, concentrates fed per livestock production unit may decline some and thus moderate the projected rise in feed requirements.

A higher population assumption of about 220 million people by 1975 would add about 5 percent to projected utilization of major farm products.

Output Required to Meet Projected Demand

Growth in demand gives purpose and direction to productive activity, but it is not the purpose of this section to give an appraisal of probable changes in output during the next two or three decades. That is, it is not an appraisal of the probable supply response to rising demands. [7]

Projected total requirements for domestic use and export would not require corresponding increases in output. Production rates in recent years have exceeded use; they resulted in substantial accumulations in stocks of wheat, rice, cotton, and feed grains. Total net stock build-up in 1953 was equal to about 6 percent of net farm output; the build-up of crop inventories was equal to about 8 percent of crop output. Although the rate of inventory accumulation was slower in 1954 and 1955 than in 1953, production continued to exceed utilization.

With production running in excess of utilization, a projected increase of around 40 percent in requirements for domestic use and export, from 1953 to 1975, may require a rise of less than a third in total output of farm products. For livestock products the increase would exceed 40 percent whereas a gain of about 25 percent is indicated for crop output (table 9).

The lower level of requirements probably would require an increase of less than a fourth in total farm output; this would imply a rise of nearly a third for livestock products and possibly a fifth for crops.

Production of livestock products as a whole would need to increase under the higher consumption rates by more than 40 percent—about 45 to 50 percent for meat animals and poultry products and more than 25 percent for dairy products. The increase in production of cattle and calves from the high output in 1953 probably would be somewhat smaller than the required increase from the relatively low level of hog production in 1953. Sheep production may increase much less than output of cattle or hogs. Production of chicken and turkey may need to increase around 50 percent and egg production around 40 percent from

[7] A more complete discussion of the nature of the production job is reported in a companion report, *Farm Output, Past Changes, and Projected Needs*, by Glen T. Barton and Robert O. Rogers of Agricultural Research Service, U. S. Department of Agriculture.

TABLE 9.—*Output of major livestock products, 1953 and projections of output needed to meet projected requirements for 1960 and 1975* [1]

[1953=100]

Commodity	1953	Projection 1960		Projection 1975	
		I [2]	II [3]	I [2]	II [3]
Livestock and products	100	-----	111	-----	142
Meat animals	100	111	111	131	146
Beef and veal	100	109	104	128	138
Lamb and mutton	100	113	110	132	114
Pork (excl. lard)	100	115	121	135	156
Wool	100	114	114	118	118
Poultry products	100	-----	115	-----	148
Chicken and turkey	100	105	115	123	153
Eggs	100	108	112	127	140
Milk, total fat solid basis	100	107	106	125	129

[1] Output required to meet projected requirements.
[2] Level I output assumes approximately current consumption rates per person for both 1960 and 1975.
[3] Level II output is based on a projection of per capita consumption reflecting the effects of an increase in real per capita income—about 60 percent from 1953 to 1975—and trends in popular consumption habits.

1953 to 1975 to match the higher level of requirements. These increases are about the same as the projected rise in utilization of livestock products.

Output increases needed to match projected requirements for 1975, based on current consumption rates, are in general smaller than those based on the higher projected consumption rates for livestock products; they would range from 25 to 30 percent for most livestock products. The higher population assumption for 1975 would require correspondingly larger expansion in output of all livestock products (table 9).

Projected requirements for crops under the higher consumption rates are up about 36 percent from 1953 to 1975. But since the net build-up of crop inventories in the 1952–53 marketing year was equal to around 8 percent of total crop output, including feed and seed, an increase of about a fourth in crop output would meet expanded requirements.

With excess productive capacity in feed grains, the higher projection of requirements for livestock products would suggest an increase of around a third in combined output of the four major feed grains—corn, oats, barley, and sorghum grains. Assuming a further decline in per capita use of wheat, projected utilization of food grains for 1975 would require a smaller output than in 1952–53.

Furthermore, very little increase in output of potatoes and beans would be needed to meet projected requirements. Expanded needs for protein feed may result in a substantial increase in output of soybeans—possibly around 60 percent from 1952–53—which would probably lead to relatively large supplies of oil available for export.

The higher projection of requirements for 1975 would call for an increase of more than 40 percent in combined output of fresh vegetables and nearly 50 percent in production of fruits; much of the gain would be in citrus fruits.

With further increases in per capita use, tobacco production would have to rise by possibly 50 percent to meet the higher level of expanded domestic

TABLE 10.—*Output of major crops, 1953 and projections of output needed to meet projected requirements for 1960 and 1975* [1]

[1953=100]

Commodity	1952–53	Projection 1960		Projection 1975	
		I [2]	II [3]	I [2]	II [3]
Crops	100	-----	103	-----	124
Feed grains	100	103	108	117	135
Food grains	100	-----	75	-----	82
Wheat	100	72	74	83	81
Rice, milled	100	103	92	109	94
Rye	100	113	130	129	138
Fruits [4]	100	-----	115	-----	141
Apples	100	104	121	124	129
Citrus	100	117	121	136	176
Other	100	106	114	130	135
Vegetables [4]	100	-----	109	-----	141
Tomatoes	100	119	119	139	165
Leafy-green and yellow	100	103	109	120	142
Other	100	99	104	116	131
Potatoes [4]	100	101	99	116	102
Dry edible beans [4]	100	110	98	124	99
Sugar	100	101	101	101	101
Food fats and oils	100	105	106	120	137
Nonfood fats and oils	100	106	112	125	138
Cotton	100	88	96	95	117
Tobacco	100	103	114	123	150
Total farm output	100	-----	106	-----	131

[1] Output required to meet projected requirements.
[2] Level I output assume approximately current consumption rates per person for both 1960 and 1975.
[3] Level II output is based on a projection of per capita consumption reflecting the effects of an increase in real per capita income—about 60 percent from 1953 to 1975—and trends in popular consumption habits.
[4] Base year is calendar year 1953.

use and export. The higher level of cotton utilization projected for 1975 would require a cotton crop about one-sixth larger than in 1953.

If the lower consumption rates are assumed, projected 1975 requirements point to need for a smaller cotton crop than in 1952–53. Even though per capita use of wheat is held at about the 1955 rate, output of wheat needed to match requirements would be well below the nearly 1.3 billion bushel 1952 crop and not much above the 1955 crop. But larger output would be required by 1975 for potatoes and dry beans if current consumption rates are assumed. The lower level of requirements for fruits, vegetables, feed grains, fats and oils, and tobacco, points to moderate increases in required output for these crops.

For both consumption levels, the higher population assumption of 220 million people by 1975 would add proportionately around 5 percent to output increases in the preceding paragraphs, which are based on a population of 210 million.

Prospective Demand for Farm Products by 1960

Some of the most pressing problems facing agriculture today revolve around the outlook for the next few years. The extent to which demand for farm products expands in coming years will be an important factor influencing programs that are designed to limit production and work down excessive stocks of some farm products. With continued growth in population and a further increase in consumer income, projected requirements for farm products by 1960 may total around 12 percent above the base year 1953. As current production rates are above 1953, and carryover stocks of some products are large, little or no further increase in output would be needed to meet projected requirements for 1960. However, some adjustment in the pattern of farm output is indicated.

To a considerable extent the small rise in per capita use of farm products projected for 1960 had already occurred by 1955. Per capita consumption of meat-animal products in total would change little from the base year 1953 and may not equal the high rate of use in 1955 when prices were relatively low. Milk consumption per person projected for 1960 and per capita use of poultry products for 1960 would be up some from 1953 levels. Per capita consumption of citrus fruits and most fresh vegetables is projected to increase from 1953 levels, in line with past trends. Although per capita use of wheat and potatoes is expected to trend downward, projections for 1960 are fairly close to current consumption rates. Per capita use of cotton and tobacco are a little above current rates (1955). Little change in per capita use of food and nonfood oils is in prospect.

Projected Requirements Rise Moderately

With population growth of about a tenth from 1953 to 1960 and a small rise in per capita use, domestic requirements for farm products would increase around 12 percent from 1953 to 1960; the required increase from 1955 may be less than a tenth. Total volume of agricultural exports are carried at levels about as large as in 1952–53. The same relative increase in requirements (12 percent) is indicated for both livestock products and crops. However, use of food grains, potatoes, and dry beans may total less than in 1953. Requirements for feed increase about the same as livestock products. Other nonfood uses, mainly cotton, tobacco, wool and oils, are projected to rise by nearly 12 percent from 1953 to 1960.

With continued population growth, per capita use of beef by 1960 may depend largely on the course of the cycle in cattle numbers during the next few years. Current trends suggest cattle numbers are at or near the top of their cycle. Projected requirements for 1960 suggest upward of 100 million head of cattle; there were 97½ million head on January 1, 1956. Thus supplies per person by 1960 may be smaller than the relatively large supplies in 1955. A total pig crop of between 100 and 105 million head is projected for 1960 compared with 95 million head in 1955. A moderate rise in requirements for dairy products is indicated. Projected requirements for poultry products, in total, increase more than an eighth from 1953 to 1960.

Required Farm Output Near Current Levels

An appraisal of output needed to meet projected utilization of farm products by 1960 requires some assumptions relative to accumulated stocks and probable production cycles. It is questionable whether a further increase in output will be needed to balance the projected increase in requirements for 1960. In 1953 we produced about

6 percent more farm products than were utilized; so an output increase of about 6 percent, with adjustments in composition, would match the projected increase of 12 percent in total requirements. With output in 1955 already up some 3½ percent above 1953, total output may be within 2 or 3 percent of that required to meet projected utilization of farm products by 1960.

Although projected requirements point to an increase in output of livestock products from 1953 to 1960, part of the gain had occurred by 1955. Cattle and calves on farms January 1, 1956 totaled 97½ million head, close to probable requirements for 1960. A pig crop of 100 to 105 million head is indicated compared with 95 million in 1955. The rise in requirements for dairy products probably can be met without increasing the number of cows milked. A larger output of poultry products is indicated by projected requirements (table 11).

The 1955 crops of wheat, major feed grains, potatoes, and cotton were about the same as the output that will be required for 1960. In addition to current high production rates for major crops, the carryover stocks are large for wheat, rice, feed grains, and cotton. Stocks of wheat and cotton exceed one year's production and feed grain stocks equal almost a third of feed grain output in 1955.

A major deviation in domestic and foreign demand from the gradual increase indicated in these calculations could modify demands by 1960. But it is clear that the supply situation could continue burdensome for food grains, cotton, and feed grains, for several years, if growing conditions are favorable. These conditions also point to the need for considerable adjustment in the pattern of farm output during the next few years.

TABLE 11.—*Production of major farm products 1955 and required output for 1960, assuming projected consumption rates*

Commodity	Unit	1955	Projected 1960
Livestock products:			
Cattle and calves on farms January 1.	Million	96.6	98.5
Pig crop	do	95.3	103
Eggs produced	Mil. doz	5,403	5,960
Milk produced	Bil. lbs	123.5	127.5
Crops:			
Wheat	Mil. bu	938	962
Major feed grains [1]	Mil. ton	130	129
Corn	Mil. bu	3,185	3,340
Soybeans	do	371	341
Potatoes	do	382	377
Cotton	Million running bales.	14.5	14.5

[1] Corn, oats, barley, and grain sorghums.

Farm Population as a Useful Demographic Concept

By Calvin L. Beale

In the development of plans for the 1960 Census of Population, the question has been raised as to whether "farm population" should be retained as a distinctive category of enumeration, or if "open country" residents should be enumerated without distinction as to whether their residences are farms. This article presents certain demographic differences that, in the author's view, argue the continuing usefulness of retaining farm residence as a distinct category for enumeration.

ONCE EVERY DECADE the planning stage arrives for the next national census of population. At such a time, the demographic concepts used in the census are reevaluated together with a host of proposals for changes. We have now come to that point in time with respect to the 1960 census.

From several sources, opinions have been expressed that separate data on farm people should no longer be obtained in the census of population or that the definition of farm population now employed needs radical modification.[1]

Residence on rural farms has been a unit of classification in censuses since 1920. But today the farm population is only 13 percent of the total, and many farm people are now involved in nonfarm industries to a degree not common in the past. Under such conditions, those who seek additional urban data in the census ask, "Is there justification for retaining in the next census the tabulation detail given to farm population in the last?" "Indeed, should the farm residence category be retained at all?"

During the period in which the majority of the people in the United States lived on farms, the censuses of population provided no statistics on the farm population. As an early student of the subject explained it, "the Nation was so largely rural that interest centered in the growth of cities."[2] The farm population was taken for granted.

But by the turn of the 20th century, the nonfarm population was rapidly drawing away from the farm population in number. As the cities

[1] For example, see the remarks of Price, Daniel O., and Hodgkinson, William, Jr., discussing the paper, NEW DEVELOPMENTS AND THE 1960 CENSUS, by Conrad Taeuber. Population Index. 22:181–182. 1956. Also, FIRST LIST OF QUESTIONS ON 1960 CENSUS SCHEDULE CONTENT, a statement prepared by the Bureau of the Census for the Council of Population and Housing Census Users. Pp. 1–2. September 1956.

[2] Foreword by Warren, G. F. to Truesdell, Leon E. FARM POPULATION OF THE UNITED STATES, 1920. Washington, D. C. U. S. Bureau of the Census. 1926. P. xi.

flourished, qualitative differences became evident. President Theodore Roosevelt motivated by concern that ". . . the social and economic institutions of the open country are not keeping pace with the development of the nation as a whole," appointed a Commission on Country Life.[3] This was in 1908. It may be significant that the term "open country" was apparently still equated with "agriculture" at that time, as the work of the Commission on Country Life dealt almost entirely with agricultural questions.

Farm Population Distinguished From Remainder

Roosevelt's plea at this time for "organized permanent effort in investigation" was reflected some years later in the creation of a Division of Farm Population and Rural Life in the United States Department of Agriculture. Dr. Charles Galpin, in charge, felt that by 1920 the census statistics on the rural population had become inadequate as a measure of conditions in the farm population. Primarily at his urging—and for use in tabulations promoted by him—the farm population was distinguished from the rest of the rural population in the 1920 census. In the census monograph in which the new material was published, few words of justification were thought necessary. It was simply stated that material differences between the farm and nonfarm population had developed and that many persons "desired an analysis of the farm population."[4] In the population censuses since 1920, the basic threefold classification of urban, rural-nonfarm, and rural-farm has been used extensively. The urban-farm population has been tallied, but as the number is so small, tabulations by characteristics have been confined to the rural-farm population, in order to achieve economy by fitting the farm residence concept into the urban-rural residence concept.

Since 1920, great changes have been wrought in the lives of farm people and in the nature of farming. The physical isolation of farm life and its concomitant social isolation from urban life have been reduced by automobiles, paved roads, and electricity. The subsistence farm is almost a thing of the past; crop specialization has increased. The farmer's cash needs have grown enormously. He needs large amounts of cash to enable him to buy the expensive equipment characteristic of modern farming and the goods and services that make up the modern standard of living. Increasing numbers of farm operators and their wives and children have taken nonfarm jobs to supplement the farm income. These statements are truisms—they have been repeated often in the last generation.

If farm and nonfarm conditions of work and living have tended to converge, are there still major differentials between the two groups of the demographic and quasi-demographic type measured by the decennial census? The answer would appear to be yes. Table 1 shows summary measures and frequency of occurence for various characteristics of the urban, rural-nonfarm, and rural-farm population. For many of these measures, substantial differences between the farm and the total nonfarm populations are evident. As the key question is whether the farm and rural-nonfarm values of the measures are different, attention here is focused on these values.

Farm population declined by 18 percent from 1940 to 1950 through heavy outmigration, while rural-nonfarm population grew at a rapid but somewhat unmeasurable rate. Through differential migration, the sex ratio in the farm population is much higher than elsewhere. (Without the military and institutional populations, the rural-nonfarm ratio of males to females is below 100.) The prevalence of nonwhite people is higher in the farm population. Educational attainment is somewhat lower in the farm population, especially for men in the prime of life. Retardation in grade reaches its most serious proportions among farm children. Cumulative fertility, both for women now bearing children and those of older age, is considerably higher for farm than for rural-nonfarm women. Differences in natural increase rates are even greater.

The mobility rate, measured by the proportion of people who move from one house to another in a year, is lower for the farm population than for the nonfarm. The average size of farm households is considerably larger than that of

[3] U. S. Cong., 60th, 2d sess., Senate Doc. 705, Country Life Commission Report. P. 21.

[4] Truesdell, Leon E. FARM POPULATION OF THE UNITED STATES, 1920. *op. cit.* P. xi.

TABLE 1.—*Selected characteristics of the population of the United States, by residence groups, 1950*

Characteristic	Urban	Rural nonfarm	Open-country nonfarm	Rural farm
Total population (millions)	96.2	31.0	20.9	23.0
Percent change in population, 1940 to 1950	23.8		NA	−17.9
Sex ratio, population 14 years and over	92.2	103.2	105.8	112.2
Percent nonwhite	10.1	8.7	9.8	14.5
Median age—years	31.6	27.9	26.5	26.3
Percent 65 years and over	8.1	8.6	7.3	7.6
Children ever born:				
Per 1,000 women 15–44 years	1,215	1,927	NA	2,420
Per 1,000 women 45–49 years	1,957	2,626	NA	3,564
Percent movers and migrants in population	17.3	20.2	23.5	13.9
Percent of movers having farm residence in 1949	4.5	18.1	18.9	62.8
Average persons per household	3.24	3.45	NA	3.98
Percent of households with female head	17.5	13.1	NA	6.3
Median age at first marriage:				
Males	23.1	22.4	NA	23.2
Females	20.6	19.3	NA	19.7
Percent single—males age 21	71.2	65.9	NA	72.6
Percent married—males 65+	65.1	64.2	61.1	70.0
Percent widowed—females 65–69 years	44.1	38.8	NA	28.6
Highest percent divorced at any age—female	4.6	2.6	NA	1.3
Median years of education:				
Persons 25 years old and over	10.2	8.8	8.7	8.4
Males 30–34 years old	12.1	10.4	NA	8.7
Percent high school graduates among males 30–34 years	52.5	38.7	NA	25.8
Percent of children 16–17 years old enrolled in school	78.8	70.2	NA	67.2
Percent of enrolled 7-year old children in 2nd grade or higher	67.1	54.7	NA	51.6
Percent in the labor force:				
Males, 14 years and over	79.3	74.1	73.4	82.7
Females, 14 years and over	33.2	22.7	21.1	15.7
Males, 65 years and over	40.0	31.3	29.1	60.6
Females, 40–44 years	40.9	30.7	NA	19.4
Median income, 1949 (dollars):				
Families	3,431	2,560	NA	1,729
Persons (males only)	2,602	1,835	1,743	1,246
Percent of civil labor force unemployed	5.3	5.1	5.4	1.7
Percent of births not occurring in hospitals	6.2	16.0	NA	33.5
Percent of infants missed by the 1950 Census	3.2	3.3	NA	5.3
Percent of population 14 years and over in institutions	.9	3.4	4.9	[1] .0
Percent of males 14 years and over in the Armed Forces	1.4	4.0	5.8	.1
Percent of employed males with farmer, farm manager, farm laborer or foreman as primary occupation	1.1	9.6	11.2	76.3

NA = Not available.

[1] No institutional population by definition.

Sources: Reports of the 1950 Census of Population and unpublished data of the National Office of Vital Statistics.

nonfarm. Differences in marital status exist, the most notable of which is perhaps the high proportion of married persons and the low proportion of widows among elderly farm residents as compared with nonfarm. A related statistic is the proportion of households having female heads—it is very low among farm people.

Labor-force participation rates are noticeably higher for farm men, particularly for young and elderly men. On the other hand, farm women have lower labor force participation than other residence groups. The percentage of the labor force enumerated as unemployed is lowest among farm residents. The average money income of farm families is lower than that of the rest of the population, allowing for difficulties in the comparison of income for farm and nonfarm classes. The proportion of births not occuring in hospitals is much higher for farm than rural-nonfarm births, and the proportion of infants missed by census enumerators is likewise greater in the farm population.

Differentials Reveal Special Problems

The significance of many of these differentials between the farm and rural-nonfarm or urban populations is that they reveal conditions of problem nature in the farm population that are not present in so severe a degree in the rest of the population. For example, the high fertility of farm people, coupled with contracting manpower needs in agriculture, necessitates outmigration at extremely heavy rates, with resulting social consequences and loss of investment to the farm population.

The low educational achievement of many farm youth leaves them unprepared either to practice modern farming or to acquire skilled nonfarm jobs. In 1954, farm families made up only 12.5 percent of all families, but they accounted for 38 percent of families receiving less than $1,000 cash income. A fourth of the farm families fall in this category.

The abnormal occurrence of such social or economic conditions among farm residents is a major factor in creating a continued demand for farm population statistics out of proportion to the relative number of farm people in the total population.

The rural-nonfarm population, as defined in the census, was largely purged of its urban elements in 1950 by the transfer of unincorporated communities of 2,500 persons or more and suburban fringes to the urban category. Despite this transfer, the rural-nonfarm population has remained a somewhat heterogeneous group, as the rural village population differs demographically in many ways from the open-country nonfarm population. Under these conditions, one must consider whether the differentials between rural farm and rural nonfarm that we have cited are also present between rural farm and open-country nonfarm. Some information on this is available from a special report of the last census.[5]

Of the differentials shown in table 1, those for sex ratio, percentage nonwhite, median age, and median income of persons are less between rural farm and open-country nonfarm than between rural farm and total rural nonfarm. Only in the case of median age is the differential cut substantially. But other differentials, including percentage of movers and migrants, percentage unemployed, percentage in the labor force, percentage married at some age groups, and percentage of population in institutions or Armed Forces are greater between rural-farm residents and other open-country residents than between rural farm and all rural nonfarm. In sum, the open-country nonfarm population remains demographically different from the farm population.

For two of the characteristics mentioned, the fact of farm-nonfarm residence involves conceptual differences that make separation of data by farm residence essential. In a basically nonfarm area, the unemployment rate is a good index of economic conditions. But, in a severe agricultural depression, unemployment rates for farm people do not reach high levels, and they run well below those for nonfarm. The reason is simple. If a man even farms at a mere subsistence level, he will usually remain technically employed under our labor-force concepts.

This fact has great relevance for all geographic analysis of unemployment. One of the major domestic questions before this session of the Congress is a program of aid to areas of prolonged economic distress. A key—and controversial—issue in the question of area assistance legislation is whether Federal aid shall be based solely on unemployment rates or on separate criteria devised to delineate distressed farming areas. It is argued that unemployment does not reflect basic conditions in farming areas as it does in nonfarm areas. Such a situation obtains whether an area is one in which farming is largely full time or one in which it is often supplementary to off-farm work.

Money income is difficult to measure for farm people, and it is therefore difficult to compare that received by farm and nonfarm people. Most farm families have income in kind from consumption of home-grown products, use of a house as part of a tenure agreement, or receipt of room or board as a perquisite of farm wage work. Statistically, this is partly offset by nonmonetary income items of nonfarm workers. However, the ability to subtract income of farm recipients from that of all income recipients in order to get a purified nonfarm series remains a basic reason for classfying income data by farm residence.

[5] U. S. Bureau of the Census, Census of Population: 1950. CHARACTERISTICS BY SIZE OF PLACE. Washington, D. C., 1953.

Another sustaining factor in the demand for farm population data is the particular responsibility that the Federal Government has assumed in the promotion and regulation of agriculture and for the welfare of farm people. In addition to agriculture, commerce and labor are economic groups recognized at the Cabinet level, but only the Department of Agriculture has a clientele that can be readily distinguished demographically. The Congress, the Department of Agriculture, the land-grant colleges, and the Council of Economic Advisers continually demand farm population data in their policymaking and research work.

Agriculture Still Big Business

The declining number of farm people brings no lessening of this interest, for agriculture remains as big a business as ever, and farm people continue to determine the land use of more than 60 percent of the land surface of the country. If anything, the administrative needs for farm population data have increased because of the far-reaching adjustments under way in farming. This is augmented by the increased sophistication in demographic matters of those responsible for agricultural policy. Some of the appropriations for agricultural purposes are allocated to the States on the basis of their share of persons resident on farms as determined in the decennial census of population.[6]

If we accept the continuing need for data on the numbers and characteristics of farm people, the problem of how to define this population remains. In 1930 and 1940, a household was included in the farm population if the enumerator or respondent considered the place of residence to be located physically on a farm. In the 1950 census, the respondent was asked the direct question, "Is this place on a farm or ranch?" Institutional residents or households paying cash rent for house and yard only are excluded.

But the censuses of agriculture, taken simultaneously, used criteria of acreage and value of production or sales to decide what places were farms. In the last census, agricultural schedules were taken for every place that a respondent said was a farm, but some of the places were disqualified in the editing process. There are, then, people listed as farm residents in the census of population whose places are not treated as farms in the census of agriculture, and a farm operator who lives in town, and not on the farm he operates, is counted as a nonfarm resident.

For analytical and administrative purposes of agencies concerned with agriculture, the lack of complete correspondence between farms and farm population is unfortunate. Nor is the present definitional situation always understood. Since 1950, more than one demographic publication emanating from land grant colleges has erroneously cited the farm definition of the census of agriculture in place of that of the census of population.

Some demographers appear to believe that the census of population definition of farm population is an attitudinal or subjective one, and is thus somehow inferior to objective questions or to definitional standards appropriate for a decennial census. As a respondent is not given a definition of a farm, there is of course a subjective element in the answer he gives. Because concern over the nature of the definition produces doubt in the minds of some regarding the utility of the data, it may be well to comment further on the definition aspect.

The writer believes that the farm question is no more subject to bias or variation through subjectivity than many other items on the census schedule; actually, the attitudinal element in this instance may have a useful discriminatory function. A point to remember is that the overwhelming majority of farms are listed as farm residences in the population census no matter what definition is used. In 1950, data from the collation sample of the censuses of population and agriculture show that 95 percent of the people living in farm-operator households as defined in the census of agriculture were numerated as farm residents in the census of population.[7] The majority of the remaining 5 percent represents families who operated farms but did not live on them, rather than families whose classification was affected because of the subjective nature of the population census inquiry.

From the same study, we know that only 7.5 percent of the people who were treated as farm residents in the population census lived on places

[6] Bankhead-Jones Act of 1935 and Research and Marketing Act of 1946.

[7] U. S. Departments of Agriculture and Commerce. FARMS AND FARM PEOPLE. 1953. P. 48.

that did not qualify as a farm under usages in the census of agriculture. Thus it is only for about a tenth of the total universe in question that the attitudinal element in the definition really comes into play. For certain purposes, it would be desirable to improve further the correspondence between the two censuses. My personal opinion is that from the viewpoint of demographic characteristics, persons with marginal connections to agriculture who term themselves farm residents are likely to be closer to the demographic norms of the core of the farm population than are those with marginal connections who call themselves nonfarm.

When singling out the question of farm residence as subjective, it should not be overlooked that subjective elements are in the rest of the urban-rural residence scheme, especially in the very refinements made in 1950, which it is proposed to extend in 1960. What objective criteria do we have for drawing the boundaries of unincorporated urban communities? The results are indisputably reasonable, but communities string out along the highway or shade off into the countryside, and the boundaries that separate urban from rural in such instances must be based on subjective decisions of the census geographers. The same comment applies to delineation of suburban fringes in metropolitan areas.

Advantages and Disadvantages of Definition

What definition should be used? As I see it, the advantages of the present definition are as follows:

1. Operationally, it is by far the simplest and cheapest form, requiring only one yes-or-no question on the schedule.

2. It provides comparability with the last census and other historical series, a property that may be rare in 1960.

3. It defines as farm residents the great majority of people whose residence is clearly agricultural under any definition. Among marginal cases it probably discriminates as meaningfully as any other definition that could be used in a population census.

4. Using this definition, farm residence has been placed on the vital statistics certificates of 33 States in the last 2 years. No one can state yet that the data from this source will prove to be comparable with that from the census. But this is the intention. The National Office of Vital Statistics has gone to much effort and expense to get farm residence on vital records. It will be unfortunate in more than one respect if it does not get population base data from at least one census for the study of vital events by farm-nonfarm residence. No other definition of farm is deemed to be usable in the vital registration system. It is well to recall that urban-rural residence is no longer obtainable for births and deaths under current urban-rural definitions.

The disadvantages of the definition appear to be these:

1. It does not provide a base population identically relatable to statistics from the census of agriculture.

2. Persons who live under the same physical circumstances, or even under the same roof, may construe differently the farm status of their home.

3. No matter how useful and valid a subjective definition may be, it is not easy to provide a precise meaning for it or to explain it to the public.

4. It does not include as farm people some families who depend solely on farming but who do not reside on farms.

The most frequent alternative proposed is to define farms as in the census of agriculture. But a battery of questions on production or sales is necessary to get accurate answers from this approach, especially for the marginal cases where the reliability of the definition now used is under question.

Other proposals would tabulate a population based on farmwork as a primary occupation or on farm income as the chief source of all income. The definition of a farm used in the census of agriculture is a broad one; it results in a maximum number of places called farms, as only $150 worth of products produced or sold in a year is required to qualify under it. Obviously, under current economic conditions, most of the people who raise only a few hundred dollars' worth of products must have other sources of income.

The self-defining definitions used in the census of population also must be considered to classify a maximum number of households as farm households. But the policy of the Department of Agriculture, which has been reaffirmed in recent months, is that its responsibility encompasses all

farms, including the small farms or those for which off-farm work provides most of the income. Data on the population primarily dependent on farming, whether revealed by income or occupation, are much needed and widely used, but they do not supplant the need for farm population data more broadly defined.

With the present and prospective high rate of growth in the nonfarm population, it is natural that the demand for more data on metropolitan areas, urbanized areas, tracts, unincorporated communities, and even city blocks should increase—and be met. The crux of the problem is how these legitimate needs can be met without digging an untimely grave for data on the farm population. Segregation of the village population in a separate class would not justify the merger of the rest of the rural population into one heterogeneous group. Maybe Univac will perform the miracles of economy that will allow us to have additional community classes and farm population, too.

Since 1950, rural sociologists have made much use of the State economic area concept in population research, even though it meant doing their own data consolidation work in the absence of economic area tabulations. This would appear to hold out the promise that certain data for the farm population, such as some of the items based on sample counts, could be published for economic areas only, without fatally compromising the needs of workers in this field. The basic interest, however, is *where* and *how many*. The administrative organization of agricultural work being what it is, this means county data for such subjects as sex, race, and age.

Summary

In sum, we are interested in a group of people whose lives are related to agriculture in greater or lesser degree, whose demographic, social, and economic characteristics still differ significantly from those of their neighbors, and who as a group are the administrative concern of various Government and private agencies. The method now used to identify these people in the census has conceptual imperfections, but for most purposes these imperfections are tolerable and are offset by the economic and operational superiority of the definition over its possible alternatives.

AGRICULTURAL ECONOMICS RESEARCH

A Journal of Economic and Statistical Research in the
United States Department of Agriculture and Cooperating Agencies

Volume X OCTOBER 1958 Number 4

Pricing Raw Product in Complex Milk Markets

By R. G. Bressler

The dairy industry is based on the production of a raw product that is nearly homogeneous—whole milk—on farms geographically scattered, and the disposal of this raw product in alternative forms—fluid milk, cream, manufactured products—and to alternative metropolitan markets. Alternative markets represent concentrations of population. These also are geographically dispersed, but with patterns imperfectly correlated with milk and product production. The problem faced in the study that formed the basis for this paper was to examine the interactions of supply and demand conditions and the interdependent determination of prices and of raw product utilization. As his paper shows, the author approaches the problem by first considering a greatly simplified model based on static conditions and perfect competition. This is modified to admit dynamic forces, especially in the form of seasonal changes in supply and demand. Noncompetitive elements are then introduced in the form of segmented markets and discriminatory pricing, based on ultimate utilization of the raw product. Finally, these models are used to suggest principles of efficient pricing and utilization, within the constraint of a classified system of discriminatory prices.

This paper was originally prepared in connection with the study of class III pricing in the New York milkshed currently being conducted by the Market Organization and Cost Branch of the Agricultural Marketing Service. The object was to develop theoretical models that would provide a framework within which the empirical research work could be organized and carried out. The paper is published here because of its evident value as an analytical tool to research workers engaged in analyzing the efficiency of alternative pricing and utilization systems for milk and other agricultural products. It should perhaps be emphasized that the theoretical models presented involve a considerable degree of simplification, and that various amendments may be necessary in the empirical analysis of any particular milk marketing situation. It should also be understood that not all analysts will necessarily concur fully with some of the stated implications of Professor Bressler's model, particularly with respect to the explanation of classified pricing wholly in terms of differing demand elasticities and the extent to which classified pricing may act as a barrier to freedom of entry. Readers with a particular interest in the economics of the milk market structure may wish to examine the AMS study, "Regulations Affecting the Movement and Merchandising of Milk," published in 1955, which also contains analyses bearing on some of the problems considered in this article.

OUR THEORETICAL MODELS are based on a number of simplifying assumptions, the most important of which are:

1. A homogeneous raw product, regardless of final use. This is later relaxed by considering the effects of qualitative differences in raw product for alternative uses.

2. Given fixed geographic patterns of production of milk and of consumption of fluid milk in local markets. This will then be relaxed (a) to permit changes associated with the elasticity of demand and supply; and (b) seasonal variations in supply and demand.

3. Transport costs that increase with distance and that, on a milk equivalent basis, are inversely related to the degree of product concentration; that is, cream rates lower than milk rates, butter rates lower than cream rates (and so on) per hundredweight of milk equivalent. Graphically, we treat these as relationships linear with distance. This does not distort our consideration of the nature of decisions, but actual determination of a margin between alternative products can only be specified in terms of actual rates in effect.

4. Total processing costs for a plant include a fixed component per year (reflecting the type of equipment available, and so on) plus constant variable costs per unit of product or per hundredweight of milk equivalent for each product handled. The effects of scale of operation are not considered originally, but these could be introduced in the analysis without difficulty.

Competitive Markets—Static Conditions

The General Model

Consider the case of a central market with given quantities of several dairy products demanded. To be specific, assume that whole milk, cream, and butter are involved. For each product we know: (1) The conversion factor between raw product and finished product; (2) the processing costs for plant operation; (3) the transportation cost to market. Neglect for the moment any byproduct costs and values. The market is surrounded by a producing area, and production, while not necessarily uniform throughout the area, is assumed to be fixed in quantity for any sub-area. Under these conditions and with perfect competition, how will the producing area be allocated among alternative products, and what will be the associated patterns of market and at-country-plant

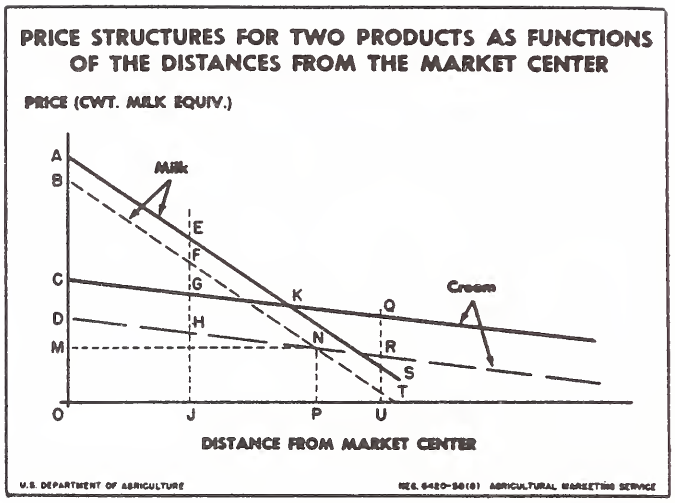


Figure 1.

prices for products and raw material? We limit our detailed discussion to the interrelations between two products, as the same principles will apply at each two-product margin.[1]

Geographic Price Structures and Product Zones

Assume that a particular set of at-market prices for products has been established. These market prices and the transportation costs, then, establish geographic structures of product prices throughout the region, so that the price at any point is represented by the market price less transportation costs. This is suggested by figure 1, where all prices and costs are given in terms of milk equivalent values. If there were no processing costs, it is clear that at-plant values for milk in whole form would equal at-plant values for milk in cream form at some distance from market, such as at point K in the diagram. But differences in processing costs do exist, and these, as well as differences in transportation costs, must be considered.

Suppose country-plant costs equal AB for milk and CD for cream. Then *net values* of the raw product at various distances from market would be represented by line BT for milk as whole milk, and by line DR for milk as cream. At any distance from market such as OJ, a plant operator would find that net value of raw product would be JF

[1] Technically speaking, we compare sets of joint products (byproducts). This modification will be covered later.

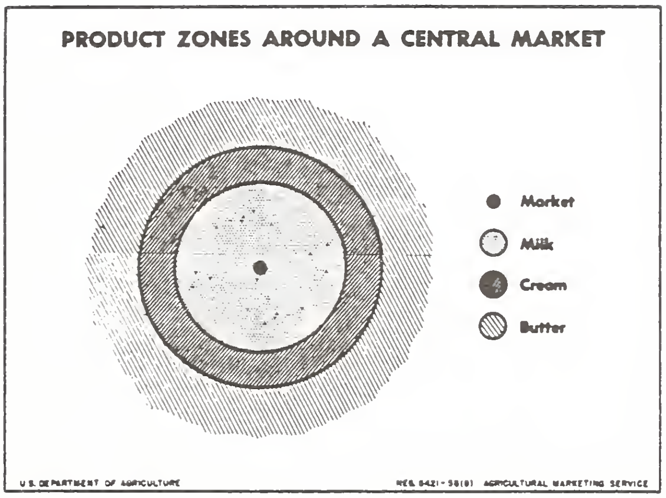


Figure 2.

for whole milk and JH for cream. Moreover, competition would *force* him to pay producers the highest value to obtain the raw product—and this would be JF. Thus, competition would lead him to select the highest value use, for in any other use he would operate at a substantial loss.

At some distance OP the net values for raw product would be exactly equal in the alternative uses. At this location, a manager would be indifferent as to the shipment pattern, and this distance would represent the competitive boundary or margin between the area shipping whole milk and the area shipping cream under the given market price. A plant operator still farther away from market would find that shipping cream would be his best alternative, in fact, the only one through which he could survive under the pressure of competition.

Disregarding the peculiar characteristics of terrain, road and rail networks, and transportation charges, this and other two-product boundaries would take the form of concentric circles centered on the market (fig. 2). The product zone for whole milk—the most bulky product with highest transport costs per unit of milk equivalent—would be a circle located relatively close to the market; zones for less bulky products would form rings around the milk zone. These rings would extend away from market until the margin of farm dairy production was reached, or until this market was forced to compete with other markets for available supplies.

In all of this, we assumed a particular set of market prices. If these had been arbitrarily chosen, the quantities of milk and products delivered to the market from the several zones would only by chance equal market demand. Suppose, for example, that the allocations illustrated resulted in a large excess of milk receipts and a deficiency in cream receipts at the market. This would represent a disequilibrium situation, and the price of milk would fall relative to the price of cream. The decrease in the price of milk would bring a contraction of the milk-cream boundary, and the process would continue until the market structure of prices was brought into equilibrium—where the quantities of all products would exactly equal the market demand.

More generally, both consumption and production would respond to price changes—demands and supplies would have some elasticity—and the final equilibrium would involve balancing these and the corresponding supply area allocations to arrive at perfect adjustment between supply and demand for all products. Notice that the product equilibria positions will be interdependent—an increase in the demand for any one product, for example, would influence *all* prices and supply area allocations. But in the final equilibrium adjustments, the situation at any product boundary would be similar to that shown in figure 1.

Minimum Transfer Costs and Maximum Producer Returns

We have demonstrated that, under competitive conditions, plant operators would select the dairy products to produce and ship by considering market prices, transportation costs, and processing costs, and that by following their own self interest they would bring about the allocation of the producing territory into an interdependent set of product zones. In algebraic terms, the at-plant net value (N) of raw product resulting from any alternative process (Products 1, 2, . . .), is represented by:

$$N = P - t - c$$

in which P represents the market price, t the transfer cost (a function of distance), and c the plant processing cost—all expressed per unit of raw product. The boundary between two alternative products 1 and 2, then, is:

$$N_1 = N_2$$
$$\text{or, } P_1 - t_1 - c_1 = P_2 - t_2 - c_2$$

It should be recognized that final equilibrium must involve higher market prices (in milk equivalent terms) for the bulky, high-transport-cost products, with lower and lower prices for more-and-more concentrated products. If this were not true, there would be no location within the producing area from which it would be profitable to ship the bulky product, and the market would be left with zero supply. Prices for these bulky products therefore "push up" through the price surfaces of competing products until market demands are satisfied.

It is easy to demonstrate that these free-choice boundaries minimize total transportation costs for the aggregate of all products, so long as market requirements are met. Suppose we consider shifting a unit of production at some point 1 in the milk zone from milk to cream, and compensate by shifting a unit of production at any point 2 in the cream zone (and therefore farther from market than point 1) from cream to milk.

The indicated shifts will represent a net increase in the distance that milk is shipped, and an exactly equal decrease in the distance that cream is shipped. But as it costs more to ship milk than cream any distance (per hundred-weight of milk equivalent), it follows that the shift must increase total transportation costs. This would be true for any pairs of points considered—the points selected were not specifically located and so represent any points within the two product zones. Moreover, a similar analysis is appropriate between any two products—the milk-cream boundary, the cream-butter boundary, and so on.

Not only do these boundaries represent the most efficient organization of transportation; they also permit the maximum return to producers consistent with perfect competition. Point 1 is located in the milk zone, and so is closer to market than point 2 in the cream zone. We know that at point 1 the net value of the product is higher for milk than for cream, while the reverse is true for point 2. Shifting to cream at point 1 would thus *reduce* the net value, and shifting to milk at point 2 would also reduce net value. On both scores, then, net values would be reduced. As net values represent producer payments (at the plant), it is clear that the competitive or free-choice boundaries are consistent with the largest possible returns to producers. From a comparable argument, it follows also that these competitive zones permit consumers at the market to obtain the demanded quantities of the several products at the *lowest* aggregate expense.

Qualitative Differences in Raw Product

We have assumed that the several alternative products are derived from a completely homogeneous raw product. Actually, the raw product will differ in quality and in farm production costs. One such difference relates to butterfat content—individual herds may vary by producing milk with fat tests ranging from nearly 3 percent to well over 5 percent.

We shall not comment on differences in the fat test other than to point out that, under competitive conditions, the determination of equilibrium prices for products varying in butterfat content simultaneously fixes a consistent schedule of prices or butterfat differentials for milk of different tests. This is true also in fluid milk markets where standardization is permitted.[2]

In many markets, milk for fluid consumption must meet somewhat more rigid sanitary regulations than milk for cream, and this involves some difference in production costs. These differences will modify our previous equilibrium analysis. Assume that farm production costs for milk for fluid purposes are higher than costs for milk for cream by some constant amount per hundredweight. The equilibrium adjustment at the milk-cream margin, then, will not involve equal net values for the raw product, for under these conditions a farmer near the margin would find it to his advantage to produce the lower cost product. The net value for milk for fluid purposes must exceed the value for cream by an amount equal to the higher unit production costs. In equation form:

$$N'_1 = N_2$$

$$P_1 - t_1 - c_1 - s_1 = P_2 - t_2 - c_2$$

in which s represents the higher farm production costs, and in which the setting of these equations equal to each other defines the new boundary.

This presentation is greatly oversimplified, though it may be adequate for present purposes.

[2] For details, see Clarke, D. A., Jr. and Hassler, J. B. PRICING FAT AND SKIM COMPONENTS OF MILK. California Agr. Expt. Sta. Bul. 737. 1953.

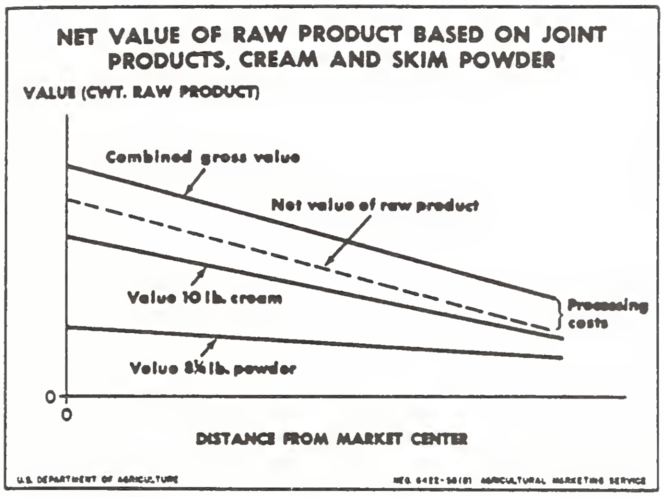


Figure 3.

Actually, differences in production costs would not enter in this simple way—for every farm would have somewhat different costs. Differences in sanitary requirements will influence farm production decisions and so modify supply. In equilibrium, the interaction of supply and demand will determine not only the structure of market prices and product zones, but also the supply-price to cover the changed production conditions. In short, this price differential will be set by the market mechanism itself, and at a level just adequate to induce a sufficient number of farmers to meet the added requirements. The cost difference that we assumed above, therefore, is really an equilibrium supply-price for the added services. Moreover, it may vary throughout a region, reflecting differences in conditions of production and size of farm.

Byproduct Costs and Values

We have assumed also that the alternatives facing a plant operator were in the form of single products. Yet it is clear that most manufactured products do not utilize all of the components of whole milk, nor use them in the proportions in which they occur in whole milk. Cream and butter operations have byproducts in the form of skim milk, and this in turn can be processed into such alternative forms as powdered nonfat solids or condensed skim. Cheese yields whey or whey solids as byproducts, plus a small quantity of whey butter. Evaporated milk will result in byproducts based on skim milk if the raw product has a test less than approximately 3.8 percent butterfat, and cream if the test exceeds 3.8 percent.

For any given raw product test, the alternatives open to a plant manager form a set of joint products, with each bundle of joint products produced in fixed proportions. With 100 pounds of 4 percent milk, for example, the joint products might be approximately 10 pounds of 40-percent cream plus 90 pounds of skim milk, or 5 pounds of butter and 8.75 pounds of skim milk powder. Net value of raw product at any location, then, will represent the quantity of each product in the bundle multiplied by market price minus transportation costs with the gross at-plant value reduced by subtracting aggregate processing costs. This is suggested in figure 3 for the joint products cream and skim powder. With this modification, our previous analysis is essentially correct. But note that the product zones now refer to joint products rather than to single products—and so to real alternatives in plant operation.

Plant Costs and Efficient Organization

Before completing our consideration of static competitive models, we should be more specific with reference to plant or processing costs. In the foregoing, these have been treated as constant allowances for particular products. As in the case of differences in production costs, processing costs are not adequately represented by a given and fixed cost allowance but rather are determined in the marketplace. In short, these too represent equilibrium supply-prices, adequate, but only adequate, to bring forth the required plant services.

In the present discussion, we have considered these in relation to the raw product and indicated a flat deduction to cover plant costs. In sections to follow we shall find it essential to distinguish between fixed and variable costs, but we shall view the process correctly as involving decisions that can be expressed ultimately in terms of costs and return per unit of raw product.

If we represent plant costs as a constant "price" resulting from the competitive market equilibrium, we disregard the effects of scale of plant. More exactly, we assume that equilibrium involves an organization of plants that is optimum with respect to location, size, and type. With these assumptions, the long-run costs for any particular type of operation are taken to be uniform and at optimum levels.

We shall proceed on this basis, but we emphasize that this will not be strictly correct, even under

ideal conditions. The optimum size for a plant of any type will depend on the economies of scale that characterize plant costs and on the diseconomies of assembling larger volumes at a particular point. These are balanced off to indicate that size of plant which results in the lowest combined average costs of plant operation and assembly.

But assembly costs are affected by such factors as size of farm and density of production: Costs increase with total volume assembled under any situation, but they increase at more rapid rates in areas with small farms and sparse production density. Consequently, the ideal plant will be of somewhat smaller scale in such areas, and plant costs (as well as combined costs) somewhat higher. Moreover, these factors will have a differential effect on costs and optimum organization for plants of different types because each type will have characteristically different economy-of-scale curves. This may mean some modifications to the perfectly circular product zones—and so provide a rational explanation of the persistence of a particular form of plant operation in what would otherwise appear to be an inefficient location.

We have suggested that competitive market conditions would balance off plant and assembly costs, and eventually result in a perfect organization of plant facilities with respect to location, size, and type. A further digression on this subject seems necessary, for these situations are unavoidably involved in elements of spatial or location monopoly. Under perfect market assumptions, the plant manager obtains raw product (and other inputs) by offering a given and constant market price, obtaining all that he requires at this price. But apparently in this country plant situation, increases in raw product can be obtained only by offering higher and higher at-plant prices—prices increasing to offset the higher assembly costs. In short, the manager is faced with a positively inclined factor supply relationship—and so finds himself in a monopsonistic situation. He cannot be unaware of this, and so he can be expected to take it into account in making his decisions.

With a given price for the finished product at the country plant location—representing the equilibrium market price minus transfer costs—and raw product cost that increases with increases in plant volume, the manager faces a price spread or margin that decreases with increases in volume.

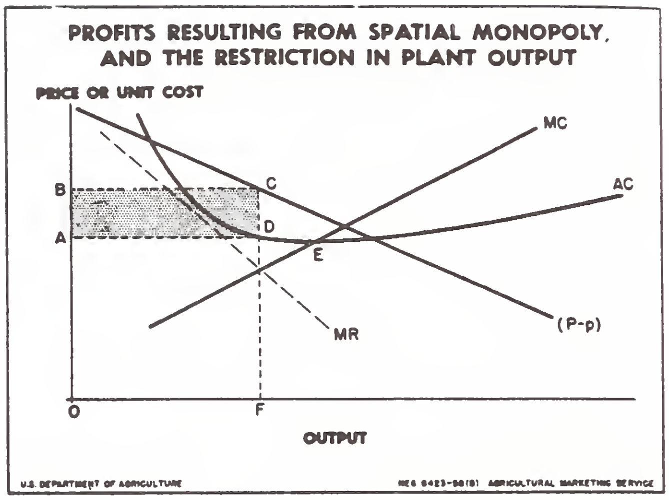


Figure 4.

This is illustrated in figure 4 by the line $(P-p)$—the at-plant finished product price (milk equivalent) minus the increasing price paid to obtain raw product. Marginal revenue from plant operation is then represented by the line MR and the manager would maximize profits by operating at output OF where marginal revenue and plant marginal costs are equal. Average plant costs would then be FD and average revenue FC, yielding monopsonistic profits equal to CD per unit or ABCD in total. Notice that optimum long-run organization would have been at point E if the prices paid for raw product had been constant rather than increasing with volume, and that this is the minimum point on the average cost curve. Because of spatial monopoly elements, however, plant volume will be lower than the cost-minimizing output, costs will be higher, payments to producers lower, and profits greater than normal.

This analysis indicates that the country organization will consist of plants with average volumes approximating OF. A plant in an isolated location would have a circular supply area, but with competition from other plants the resulting pattern of plant supply areas would resemble the large network of hexagonal areas shown in figure 5. But with excess profits, the industry would attract new firms, and they would seek intermediate locations such as points D, E, and F. A new plant at point E will compete for supplies with the established plants and eventually carve out a triangular area (HJM) with half the volume of the original plant areas. Such entry will continue until the entire

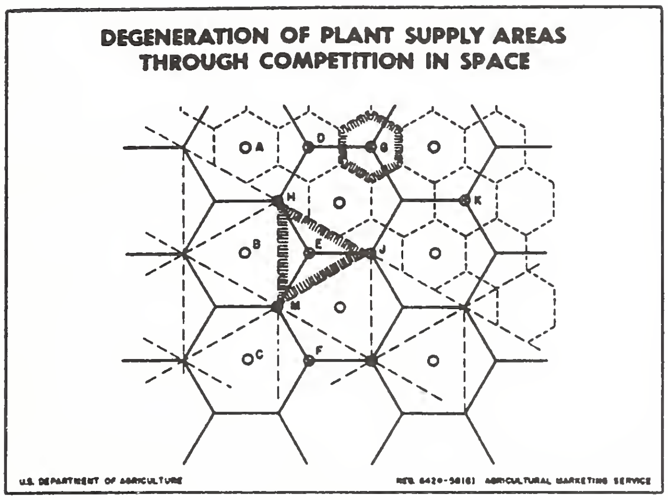


Figure 5.

district has been reallocated—with twice as many plants, each handling half the original average volume.

But this is not the end, for still more plants can force their way into the area, occupying such corner positions as H, M, J, G, and K on the triangular plant areas. Again the district will be reallocated among plants, eventually forming a new hexagonal network as shown around point G—now with three times as many plants as in the original solution. This entry of new firms might be expected to continue until excess profits disappear, or until line $P-p$ in figure 4 is shifted to the left so far that it is tangent to the average cost curve.

But even this is not the limit. The regular encroachment of new firms will result in increased costs and so make it impossible for any firms to be efficient. With a regular increase in costs for all plants, the market price (P) for the product will be forced up and the producer prices for raw product (p) forced down—in short, competition is not and cannot be effective in bringing about low costs and the optimum organization of plants and facilities.

Within this framework of industry inefficiency, there are still opportunities for firms to operate profitably and efficiently through plant integration and consolidation. When the situation becomes bad enough, a single firm (private or cooperative) may buy and consolidate several plants in a district, thus returning the overall organization toward the efficient level. But now the whole process could start over again, unless single firms were able to obtain real control of local supplies, and thus prevent the entry of new firms.

In any event, it is clear that spatial monopoly creates an unstable situation and can be expected to result in an excessive number of plants and correspondingly higher-than-optimum costs. This tendency is sometimes called "the law of mediocrity," and its operation is not limited to country phases of the dairy industry. In retail milk distribution, for example, the overlapping of delivery routes reduces the efficiency of all distributors, and so limits the effectiveness of competition in bringing about an efficient system. The mushrooming of gasoline stations is a familiar example where spatial monopoly and product differentiation result in a type of competition that is unstable and inadequate to insure efficiency in the aggregate system.

Competitive Markets—Seasonal Variation

Seasonal Changes in Production, Consumption, and Prices

We now complicate our model by recognizing that production and consumption are not static, but change through time. Specifically, we consider seasonal changes, and inquire into the effects of these on prices and product zones. Even a casual consideration of this problem will suggest that such supply and demand changes must give rise to seasonal patterns in product prices. These in turn affect the boundaries between product zones through seasonal contractions and expansions. As a consequence, the boundary between any two products is not fixed but varies from month to month, and between zones that are always specialized in the shipment of particular products there will be transitional zones that sometimes ship one product and sometimes another.

We shall now examine this situation in detail to learn how such seasonal variations influence firm decisions, and so understand how prices and product zones are interrelated. We maintain the assumption of perfect markets and the other postulates of our first model, except the assumption of constant production of milk and consumption of fluid milk. As we are interested primarily in how seasonal changes influence the system, we only specify a more or less regular seasonal cycle without attempting to delineate any particular pattern. We assume that managers act intelligently in their own self interest and are not misled by some common accounting folklore with respect

to fixed costs—although this is more a warning to our readers than a separate assumption, as it is implicit in the assumption of a perfect market.

A Firm in the Transition Zone

The general outlines of product zones with seasonal variation is suggested by figure 6. Here we show a specialized milk zone near the market, which ships whole milk to market throughout the year. Farther out we find a specialized cream zone, shipping cream year-round, while still farther from market is a specialized butter area. Between these specialized zones—and overlapping them if seasonal variation in production is quite large—are diversified or transition zones: a zone shipping both milk and cream; and a zone shipping both cream and butter.

Suppose we select a location in one of the transition zones, and explore in detail the situation that confronts the plant manager. To be specific, we shall select a plant in the milk-cream zone, but the general findings for this zone are appropriate for other diversified zones.

We assume that this plant serves a given number of producers located in the nearby territory and that this number is constant throughout the year. Production per farm varies seasonally, however, so that even under ideal conditions the plant will have volumes less than capacity during the fall and winter. We assume that the plant is equipped with appropriate separating facilities so that it can operate either as a cream shipping plant or, by not using the separating equipment, as a whole milk shipper. We further assume that market prices for milk and cream vary seasonally and that in order to meet market demands in the low-production period, milk prices change more than cream prices. With the given plant location and transportation costs to market, this means that the manager is faced with changing milk and cream prices f. o. b. his plant. Our problem is to indicate the effects of these changes on plant operations.

Consider first the cost function for this plant. Under our general assumptions, variable costs are easy to handle—each product is characterized by a given and constant variable cost per unit of output, and the manager can expand output along any line at the specified variable cost per unit up to the limits imposed by the available raw prod-

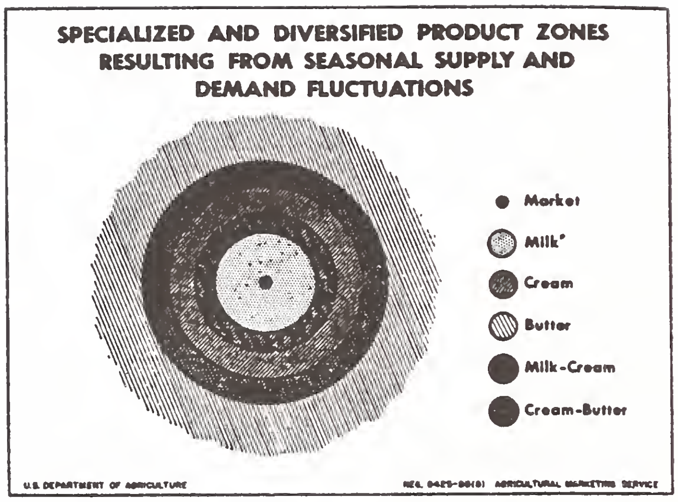


Figure 6.

uct and by plant equipment and capacity. At the same time, the plant is faced by certain fixed or overhead costs. These fixed costs are independent of the volumes of the several products, but reflect the particular pattern of plant facilities and equipment provided. So far as fixed costs are concerned, the several outputs must be recognized as joint products. There are any number of ways in which fixed costs might be allocated among these joint products but all are arbitrary.

Fortunately, such allocations are not necessary to the determination of firm policy and the selection of the optimum production patterns—in fact, fixed cost allocations serve no purpose except perhaps to confuse the issue. We take the fixed costs as given *in total* for the year—although even this is arbitrary for the outputs of any 2 years are also joint products and the assumption of equal fixed costs per year is thus unjustified.

The important issue is that the firm should recover its investment over appropriate life periods—if it does not, it will not continue to operate over the long run; if it more than recovers investments (plus interests, etc.,) then the abnormal level of returns will attract new firms and reduce profits to the normal level. Many of the fixed costs associated with investments and plant operations are institutionally connected to the fiscal year, however, and for this reason the assumption of given total fixed costs per year appears to be appropriate. Examples include annual interest charges, annual taxes, and annual salaries for management and key personnel.

In terms of total costs (fixed plus variable) per year, we visualize a surface corresponding to an equation of the type:

$$TC = a + bV_1 + cV_2$$

in which a represents annual fixed costs, V_1 and V_2 the annual output of the two products, b the variable cost per unit of product 1, c the variable cost per unit of product 2, and so on—this may readily be expanded to accommodate more than two products. Note that this cost surface does not extend indefinitely, as V_1 and V_2 are limited by available raw product and plant capacity. Gross revenue for the plant is represented by product outputs multiplied by appropriate f. o. b. plant prices, or:

$$TR = P'_1V_1 + P'_2V_2$$

Net returns—or net value of raw product in our earlier expressions—is represented by total revenue minus total costs, or:

$$NR = TR - TC = P'_1V_1 + P'_2V_2 - a - bV_1 - cV_2.$$

If the manager wishes to maximize his net returns—and under perfect competition he has no alternative if he is to remain in business—he can do this by computing the additions to net revenue that will accompany the expansion of either product and selecting the product that yields the greater increase. Marginal net revenue functions are:

$$\frac{\partial NR}{\partial V_1} = P'_1 - b$$

$$\frac{\partial NR}{\partial V_2} = P'_2 - c$$

These marginal functions may be made directly comparable by expressing them in milk equivalent terms, in which y_1 and y_2 represent the respective yields per hundredweight of raw product:

$$\frac{\partial NR}{\partial y_1 V_1} = (P'_1 - b)y_1$$

$$\frac{\partial NR}{\partial y_2 V_2} = (P'_2 - c)y_2$$

By observing marginal net values per unit of raw product, the manager can determine which product to ship. Remember that total output is limited by the available supply of raw product, and that we have assumed capacities adequate to handle this supply in either product. With given at-plant prices and constant marginal costs, the marginal net value comparisons will indicate an advantage in one or the other product, and net revenue will be maximized by diverting the entire milk supply to the advantageous product.

In algebraic terms, we state the following rules for the manager:

if $(P'_1 - b)y_1 > (P'_2 - c)y_2$, ship only product 1;
if $(P'_1 - b)y_1 < (P'_2 - c)y_2$, ship only product 2;
if $(P'_1 - b)y_1 = (P'_2 - c)y_2$, ship either 1 or 2.

These assume, of course, that prices exceed marginal costs; if marginal net revenues should be negative for all products, the optimum short-run program would be to discontinue operations entirely, but normally long-run considerations would dictate a program based on the product with least disadvantage. The third rule simply covers the chance case in which marginal net revenues per unit of raw product are exactly equal in the two lines of production, and so the choice of product is a matter of indifference.[3] Note that these optimum decisions in no way depend on fixed costs or on any arbitrary allocation of fixed costs.

We have stated that prices f. o. b. the plant will vary seasonally, with milk prices fluctuating over a wider range than cream prices. As these prices change, marginal net revenues will change—marginal net revenues from milk shipment will increase relative to marginal net revenues from cream shipments during low-production months and will decrease during months of high production. The manager will watch these changes in marginal net revenue. If $(P'_1 - b)y_1$ always exceeds $(P'_2 - c)y_2$, then the plant will always ship whole milk, and therefore must be in the specialized milk area. But if marginal net revenue from milk shipment is always lower than marginal net revenue from cream shipment, optimum plant operation will always call for cream shipment and the plant will be in the specialized cream zone.

[3] Under these conditions, the plant might ship both products simultaneously. Under other conditions, such simultaneous diversification would be optimum only if (a) capacity for a particular product is not adequate to permit complete diversion of the raw product, or (b) either marginal costs or marginal revenues change with changes in plant output. These appear to be unrealistic under the conditions stated, and so are disregarded.

If this plant is in fact located in the diversified milk-cream zone, then during some of the fall and winter months the marginal net revenue from milk will exceed the marginal net revenue from cream and the plant will ship only milk. But during some of the spring and summer months, these marginal net revenues will be reversed, and the plant will ship only cream. Day-by-day and week-by-week the manager will make these decisions, and the result will be a particular pattern of milk and cream shipments. If the plant is located near the inner boundary of the transition zone, it will ship milk during most of the year and cream during only a few weeks or even days at the peak production period. Conversely, a plant near the outer boundary of this zone will ship cream during most of the year and milk only for a few days at the very-low-production period.

Specialized Milk Versus Milk-Cream Plants

It may be protested that the foregoing analysis is incorrect because a plant that utilizes its separating equipment for only a few days must have very high cream costs. This is a common misunderstanding; it arises from the practice of allocating fixed costs to particular products. Nevertheless, a grain of truth is involved, and it can be correctly interpreted by considering the alternatives of specialized milk plant or milk-cream diversification near the milk and milk-cream boundary.

We have seen that the net value of raw product for the diversified plant can be represented by:

$$NR_{12}=P'_1V_1+P'_2V_2-a-bV_1-cV_2$$

In a similar way, we represent net values for the specialized milk plant as:

$$NR_1=P'_1V-d-bV$$

in which d represents the fixed costs for a specialized milk plant and b the variable costs—we assume variable costs of shipping milk as the same in the two types of plant, although this may not be true and is not essential to our argument.

In our equations prices are given in terms of the milk equivalent of the whole milk or cream, and expressed at country-plant location. Remembering that the at-plant price is market price less transportation cost to market and that transportation costs are functions of distance, these costs can be used to define the economic boundary between the specialized milk plant zone and the transition milk-cream zone. For simplicity, we represent the transportation costs by t_1D and t_2D, and give the expression for the distance to the boundary of indifference below:

$$D=\frac{(P_1-b)-(P_2-c)+\frac{a-d}{V_2}}{t_1-t_2}$$

Note that this boundary is long-run in nature—it defines the distance within which it will not be economical to provide separating facilities but beyond which plants will be built with such facilities.[4] The short-run situation would be represented by the margin between specialized milk shipment and diversified milk-cream shipments *where all plants are already equipped to handle both products*. From the material given earlier, it is clear that the equation for the short-run boundary will be exactly the same as the long-run equation, *except* that the fixed costs term $\frac{a-d}{V_2}$ will be eliminated. From this it follows that the long-run boundary will be farther from market than the short-run boundary. If a market has reached stable equilibrium, separating facilities will not be provided until a substantial volume of milk can be separated.

The actual determination of these boundaries will depend on the specific magnitudes of the several fixed and variable cost coefficients, the patterns of seasonal production, the relative transfer costs, and the patterns of seasonal price changes. Ideally, these all interact to give a total equilibrium for the market. We may illustrate the solution, however, by assuming some values for the various parameters and seasonal patterns. This has been done, with the results shown in figure 7. Here we have assumed that fluid milk prices change seasonally—the prices minus unit variable costs at country points are represented by line AB

[4] We assume that equipment will have adequate capacity to handle total plant volume. There remains the possibility that a plant would provide some equipment for a particular product, but less than enough to permit complete diversion. As equipment investments and operating costs normally increase less rapidly than capacity, it usually will pay to provide equipment to permit complete diversion of plant volume if it pays to diversify at all.

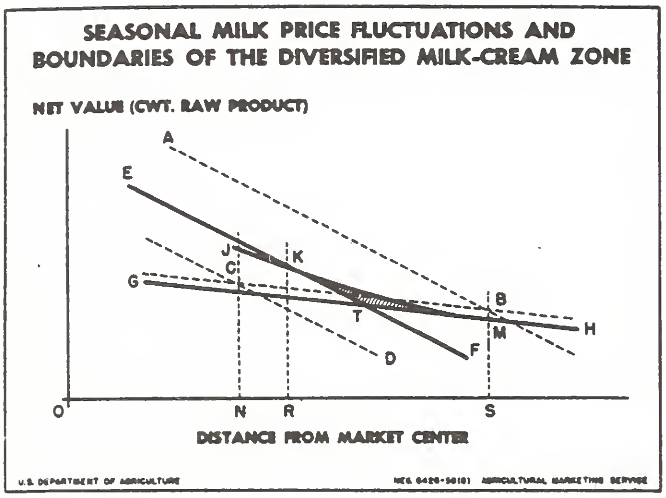


Figure 7.

for the high-price season and line CD for the low-price season. We have assumed that cream prices are constant. Although this is not strictly correct, it will permit us to indicate the final solution in somewhat less complicated form than otherwise would be necessary. The geographic structure of cream prices less direct variable costs is represented by line CB. Apparently, the short-run boundary between the specialized milk zone and the milk-cream zone would be at distance ON, for at point C net raw product values would be equal in either alternative. Similarly, the outer short-run margin between the milk-cream zone and the specialized cream zone would be at distance OS.

Consider the long-run situation where decisions as to plant and equipment are involved. For convenience, express all net values in terms of the averages for the entire year. The net value of raw product from specialized milk plants is represented by line EF. This line is a weighted average of such lines as AB and CD—each weighted by the quantity of milk handled at that particular price—the line represents the seasonal weighted average price minus direct variable cost *and minus* annual average fixed costs d/v per unit of raw product. In other words, this net value line is long-run in that it shows the effects of fixed costs as well as variable costs and seasonal price and production changes. Similarly line GH represents long-run net value of raw product in specialized cream plants differing from CB by the subtraction of average fixed costs a/v. Apparently, the economic boundary between specialized milk and specialized cream plants would be at point T *if we prohibited diversified operations.* But we know that plants equipped with separators would find it economical to diversify seasonally in zone NS.

The increase in net value realized by cream plants through seasonal milk shipments is represented by the curved line JKM in the diagram. As we start at point M on the outer boundary of the diversified zone and move to plants located closer to market, an increasing proportion of the raw product during any given year will be shipped to market as whole milk. These milk shipments occur during the low-production season, as milk prices are then at their highest levels. Observe that these plants are covering total costs—including the costs for fixed separating equipment, even though a smaller and smaller volume of milk is separated. That is, the dominant consideration in this situation is the opportunity for higher net values through milk shipments—and not higher costs based on an arbitrary allocation of certain fixed costs to a diminishing volume of cream. Notice also that, under competitive conditions, plants must make this shift to milk shipment. Otherwise, they could not compete for raw product and so would be forced out of business.

Although plants equipped with separating equipment would find it economical to ship small volumes of cream in the low-price period even from the zone NR, the gains would not be adequate to cover the long-run costs of supplying separating equipment. This means that specialized milk plants—without separating equipment and so with lower fixed costs—are more economical in this zone. This is indicated by the fact that line JKM falls below the net value line EF for specialized milk plants in the JK segment. The boundary specified by our long-run equation is found at distance OR, where net long-run values are equal for specialized milk plants and for diversified plants—RK. Plants at this boundary would find it economical to ship cream for a month or two each year if they shipped cream at all. This abrupt change from specialized milk plants to plants shipping a fairly substantial volume of cream is a reflection of the added fixed costs, and this represents the previously mentioned grain of truth in the usual statements about the high plant costs involved in shipping low volumes of cream or similar products.

Noncompetitive Markets

Price Discrimination and the Classified Price System

No matter how revealing the theory of competitive markets may be, it is clear that it cannot apply directly to modern milk markets. Milk, cream, and the several manufactured dairy products serve different uses, and are characterized by different (although to some extent interrelated) demands. Moreover, bulkiness of product and high transportation costs segregate fluid milk markets, and this segregation is at times enhanced by differences in sanitary regulations. In any market, as a consequence, there will be a relatively inelastic demand for fluid milk and a somewhat more elastic demand for cream. Most of the manufactured products produced in the local milkshed must be sold in direct competition with the output of the major dairy areas, and so the demands for these products in the local market normally appear to be quite elastic to local producers. It should be recognized, however, that some manufactured products are rather bulky and perishable, and so may have a local market somewhat differentiated and segregated from national markets.

Differing demand elasticities for alternative dairy products long ago gave rise to systems of price discrimination. Here we refer to differences in f. o. b. market prices that are greater than, and unrelated to, the differences resulting from differences in processing costs, transfer costs, and the costs of meeting any higher sanitary requirements. In addition, producers in most markets have developed collective bargaining arrangements in dealing with milk distributors. These have commonly resulted in some form of classified pricing, under which handlers pay producers according to a schedule with different prices based on the final use made of the raw product. Whatever else may be said about classified pricing plans, it is clear that they involve price discrimination in several segments of a market. Thus, a completely homogeneous raw product may be priced at different levels according to the use made of the product. Because of the nature of available substitutes and so of demand elasticities, these classified or use prices are normally highest for fluid milk, lower for milk used as fluid cream, and lower still (and approximating competitive market levels) for the major manufactured dairy products.

We need not explore the theory of price discrimination here—its general conclusion that products should be allocated among market segments so as to equate marginal revenues in all segments and equate these to marginal costs is familiar enough. We point out, however, that these principles refer to the maximizing of profits or returns through price discrimination. Although price discrimination is the rule in fluid milk markets, it is doubtful whether it ever is carried to the point representing maximum returns, at least in any short-run sense. But prices do move away from competitive levels in the directions indicated by the theory, and returns are increased even though they are not necessarily maximized.

To avoid misunderstanding, we emphasize that considerations of supply as well as demand are involved in milk pricing. We have already pointed out that the demands for the major manufactured products appear to be perfectly or nearly perfectly elastic to sellers in the local market. Supply diversions to and from the national market keep prices in line in the local market, and the impact of local supplies is relatively insignificant in the national market. These diversions and the impracticability of market exclusion prevent significant price discrimination.

Similar diversions are physically possible for fluid milk, although at relatively higher transportation costs, and in a perfect multiple-market system all prices would be interdependent through supply and demand interactions. But here market exclusion is both practical and practiced, through such devices as differences in sanitary regulations, refusal to inspect farms beyond the normal milkshed, refusal to certify farms as "Grade A" unless they have a fluid milk market, and provisions of a variety of pooling plans and base or quota arrangements.

The classified price system itself is an effective barrier to entry if it is enforced by an agency with power extending across State lines, for this plan effectively eliminates the incentives for milk dealers to reach out and buy milk from low-priced and unregulated sources. Even in the absence of complete jurisdiction, classified prices may make market entry difficult through general acceptance of the pricing plan by dealers in any given market.

These and other market exclusion devices may be far from perfect, however, especially over a period of time. Class I prices at discriminatory levels may encourage expanded production by present and new producers within the existing milkshed and so may dilute composite prices through a growing proportion of surplus milk. High prices may encourage consumers to seek substitutes and thus increase the elasticity of long-run demands. Fear of popular rejection of pricing schemes, plus concern of the regulating agency for the public interest, may place effective ceilings on class I prices, even though short-run demands are inelastic.

All of these and other considerations influence and limit the operation of classified pricing plans. But extreme differences between class I and surplus prices, between prices in alternative markets, and between prices paid to neighboring farmers provide evidence that barriers to market entry are important in fluid milk markets and that discriminatory prices for fluid milk exploit these effective barriers. This evidence is bolstered by reports of attempts to restrain increases in production and supply, and of shifts to milk pricing under Federal authority when State price regulation becomes ineffective.

From our present standpoint, the important aspect of classified pricing is that this system establishes a schedule of prices *to be paid to farmers* by handlers, and that these prices refer to specific alternative uses for the raw product. We add a second aspect that is appropriate for the New York market, although not for all fluid markets: the market is operated on the basis of a marketwide pool. This means that the classified prices paid by handlers do not go directly to their producers but in essence are paid into a pool. All producers are then paid from the pool on an uniform basis, after appropriate adjustments for butterfat test and for location.

Three important modifications are thus required in our foregoing theory: (1) At-market prices will no longer represent competitive equilibrium levels; (2) returns to producers in any locality are not directly influenced by the particular use made of their milk—prices paid producers by two plants will be uniform pool prices even though the plants process and ship quite different products; and (3) the analysis in terms of net values of raw product must now reflect firm decisions when raw product is priced by a central agency—where raw product costs are determined by classified prices rather than directly by competition.

Classified Prices and Managerial Decisions

We have seen that, under competitive conditions, plant managers would tend to utilize milk in optimum outlets in order to meet competition and so survive, and that these optimum use patterns would depend on market prices and on transport costs. With classified prices and market pooling, however, the raw product cost to a plant is determined by the particular use pattern, while payments to producers from a market pool are a reflection of the total market utilization. As a consequence, producer payments will be fixed for any location regardless of utilization; they cannot be effective in encouraging optimum use patterns. The plant manager is now faced with the problem of maximizing his returns when faced on one hand with a set of market prices for products and on the other by a set of classified prices for raw product.

Suppose we begin our examination of this problem by assuming that market prices and transportation costs are given and fixed—thus fixing the particular set of product prices f. o. b. the country plant at any specified location. Assume also that classified prices are established to reflect as closely as possible the net values of the raw product in any use. This means that the gross value of products of a hundredweight of milk will be reduced to net value basis by subtracting the efficient processing costs, and that these net values will be further reduced by subtracting appropriate transfer costs. In short, the net value curves in the previous diagrams will now represent classified prices for any particular use and at any specified location.

Although this might appear to be an ideal arrangement at first glance, further consideration will indicate that such a system would completely eliminate the economic incentives that could be expected to yield optimum use and geographic patterns. We have indicated that actual payments to producers are divorced from the particular plant utilization under marketwide pooling, and so there is no incentive for a producer to shift

from one plant to another. By the same token, the threat of losing producers because of low producer payments is no longer a problem for the plant manager.

Moreover, if processing and transportation costs are reflected accurately in the structure of classified prices, the manager will find that he can earn only normal profits, but that he will earn these normal profits regardless of the use he makes of the raw product. Under these assumptions, then, utilization patterns through the milkshed will be more or less random and chance.

This can be made clear by considering the plant profit function. We have defined net values for the raw product in terms of product prices at the market, transfer costs, and plant operating costs. Now we subtract raw product costs as specified by classified prices, and for a diversified plant we define profits as follows:

$$\begin{aligned}\text{Profit} = (P_1 - t_1 D) V_1 + (P_2 - t_2 D) V_2 - a - bV_1 \\ - cV_2 - C_1 V_1 - C_2 V_2\end{aligned}$$

in which C_1 and C_2 are the established class prices at this plant location. These are defined perfectly to reflect net values, as noted above, or:

$$C_1 = P_1 - t_1 D - b - d/V_1$$

$$C_2 = P_2 - t_2 D - c - (a - d)/V_2$$

Notice that the last terms in these equations refer to fixed costs—d for specialized milk plants, and a for diversified plants. If these values for the classified prices are substituted in the profit equation, the result is zero excess profits (normal profits, of course, are included as a part of plant operating costs). In short, with these perfectly calibrated classified prices, there would be no abnormal profits, but normal profits could be earned with any product combination and at any location.

Significantly, marketwide pooling makes this a stable situation by removing any direct impact of a plant's utilization pattern on payments to the producers who deliver to this plant. Suppose we assume that the market pool is replaced by individual plant pools (these would differ from the familiar individual handler pools if handlers operate more than one plant). Maintain all of the above assumptions, so that the manager will still earn only normal profits regardless of location or product mix. The product mix or utilization pattern would now have a direct bearing on producer payments, however, and this would modify the situation.

Consider two neighboring plants in what would normally be the milk shipping zone. Assume that, as profits would be equivalent, one manager elects to ship milk and the other cream. As the classified price for milk will be higher than the classified price for cream use in this zone, the first plant will pay its producers a substantially higher price than the second. This creates producer dissatisfaction, and some transfer of producers and volume from the second plant to the first. The individual plant pool, therefore, would provide a real incentive through the level of producer payments to bring about the optimum utilization of the raw product.

Let us now make our models more realistic by admitting that market prices for the several products are determined by supply and demand rather than being given and fixed. Classified prices are fixed by the appropriate agency. In some instances, they are tied to market product prices through formulas. To fix ideas, assume that the price for fluid milk delivered to the market is free to vary in response to changes in supply and demand; that the class I price is fixed at some predetermined level and with location differentials accurately reflecting transfer costs; that other product prices (cream, butter, . . .) respond primarily to supply and demand conditions in a national or regional market and so may be considered as given in the market in question, but subject to variation through time; and that class II and other classified prices are tied to product prices as accurately as possible through net value formulas and transfer cost differentials.

Under these conditions, plant profits in nonfluid milk operations would be uniform regardless of specific use or location. Product prices would move with national market conditions, but class prices would change in perfect adjustment to product prices. Prices of fluid milk, however, would move up or down relative to the established class I price, sometimes making fluid milk shipment more profitable and at other times less profitable than the nonfluid outlets. Under the assumed conditions, moreover, all of the available raw product would be attracted into or moved out of class I—there would be no graduated supply curve with prices adjusting until the quantities demanded just equaled the quantities offered.

Without going further, it should be clear that efficient utilization of raw product under a system of classified prices can be expected only if the pricing provisions put premiums on optimum uses. These premiums may take the form of larger profits from plant operations, or competitive losses in plant volume, or both. The pricing system must make the manager "feel" the advantages (profits and available raw product) of efficient utilization, and the disadvantages (losses and diminishing raw product supply) of inefficient use, so that his responses and adjustments will lead toward the optimum organization for the entire market. In the following section, we explore several methods of providing such incentives.

Pricing for Efficient Utilization

At the start of this section, we should make clear what we mean by efficient utilization. Earlier, we pointed out that a competitive system of product zones and equilibrium market prices mean aggregate transportation costs as low as possible. This will be true of such zones even if product prices are determined monopolistically—the most efficient organization of product zones will be consistent with competitive prices. Stated in another way, if we disregard market prices and simply determine the organization of processing throughout a milkshed that will minimize the transfer costs of obtaining specified quantities of the several products, the resulting zones will be the same as would characterize a market with competitive prices.

In the language of the linear programer, we say that the solution of the system of competitive prices among products and markets involves a *dual* solution in terms of minimum transfer costs. In the same sense, the solution of the problem of minimizing transfer costs involves a dual solution in terms of competitive prices—but these are *shadow* prices and need not correspond to actual prices. In the latter instance, of course, the allocations of producing areas will be consistent with the set of competitive shadow prices; they will not represent the free choice areas consistent with the noncompetitive prices.

This dual efficiency solution extends far beyond the minimizing of transportation costs. Suppose we have given the geographic location of production, processing costs, transportation rates, and quantities of the several products required at the market. Given this information, it is possible (though often involved) to develop a program that will supply the market with these quantities, allocate products by zones in the milkshed, minimize the combined aggregate costs of transportation and processing, and *return the highest aggregate net value* to the raw product.

If in this model we have specified efficient levels of processing costs, the resulting allocation will represent the ideal "long-run"solution with plants perfectly organized with respect to type and location. But we can enter specific plant sizes, locations, and types in the model, and obtain the best possible solution within these restraints—the optimum short-run solution. In our present context, however, we take efficient utilization to mean the optimum long-run pattern as described above, and we emphasize that this will mean the largest possible aggregate return to the raw product within the restraints imposed.

We have suggested a modification to the pricing system that might make plant managers feel the consequences of inefficient utilization—the elimination of marketwide pooling and the substitution of plant pools. This modification would be effective if the high-use plants had outlets for more and more fluid milk, but this is patently unrealistic on a total market basis. Under most circumstances, there would be little incentive under classified prices and plant pools for a plant to take on additional producers. Often, more producers would only add to the nonclass I volume of milk in the plant and so would lower the blend price to all producers. It is common observation that marked differences between the blend prices received by producers can exist and persist for long periods of time. Therefore, this is not a very dependable way to obtain improved efficiency in utilization, and it has serious deficiencies from the standpoint of equity of individual producers.

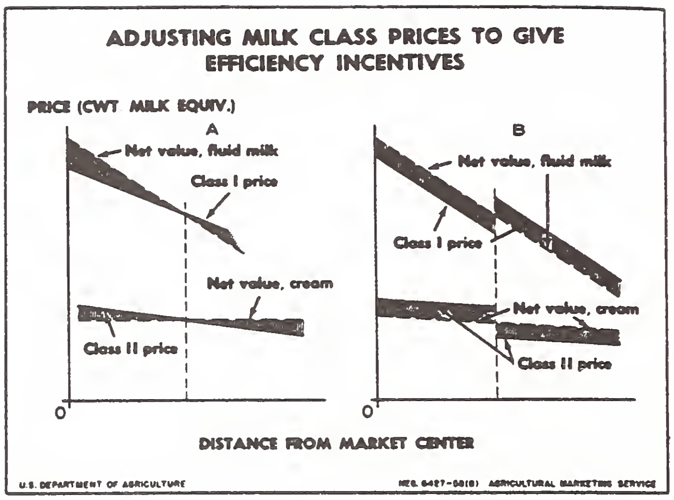
The real answer to this problem is to establish a pricing system that permits handlers to participate in the gains from efficient utilization. This means that class prices throughout the milkshed must depart somewhat from the perfect net values of raw product discussed earlier—some of the higher net values resulting from optimum utilization and location must go to handlers. Perhaps

this should be called the principle of efficient pricing. We shall not attempt to guess at the magnitude of the required incentives, other than to express an opinion that reasonably small incentives should bring fairly substantial improvements in utilization.[5] Neither shall we attempt to spell out the detailed modifications to a classified pricing system that would provide such incentives. But in the paragraphs that follow we do note some types of adjustments that appear to be consistent with this principle.

1. If products are ranked according to at-market equivalent values, the at-market allowances to cover processing costs should exceed efficient levels for the high-value products but be less than cost for the low-value products. Furthermore, the geographic structure of class prices should decline with distance from market less rapidly than transportation costs for low-value product. Note that these work together to give an incentive structure favoring high-value (and bulky) products near the market and low-value (and concentrated) products at a distance from market.

Handlers shipping fluid milk from plants located in the nearby zone receive a "premium" in the form of the difference between the net value in fluid use and the class I price. If these same plants elect to ship cream, the class II price will exceed the net value of cream and so a "penalty" will result from this inefficient use of milk supplies. The converse would be the case for plants located in the more remote parts of the milkshed. Ideally, these incentives should be equal at a distance consistent with the efficient milk-cream boundary, and similar zone boundaries for other product combinations. This is suggested by the construction in figure 8–A.

2. As an alternative to the blending together of incentives as suggested above, a more effective device might be one that provides the desired incentives through a uniform combination of "pre-



Figures 8–A and 8–B.

miums" and "penalties.". These would favor efficient production in any specified zone, making the incentive effective by a reduction in the appropriate class price for the specified zone and an increase in class prices in alternative "nonefficient" zones. The reduction in class prices is essentially similar to the provisions that permit an "incentive" reduction in the class III price for butter or cheese uses, but these specify the incentive for particular time periods while the above relate to specified distance zones (figure 8–B).

3. When several products are included in a single class for pricing, a class price that reflects a low margin on the lowest value (at-market) product will discourage its production and encourage utilization for the higher value products within the class. At the same time, this procedure can be expected to establish "subzones" within the major zone. In this way, relatively bulky, high-value, high-margin products will tend to be produced near the inner boundary of the manufacturing zone, while the more concentrated, low-value, low-margin products are confined to the more distant edges of the milkshed.

4. Corollary to (3), limiting surplus classes to one or two, with a number of alternative product uses in each class, will tend to improve utilization efficiency and also simplify administrative problems. It must be recognized, however, that this will reduce returns to producers if wide and persistent differences in product values exist within a given class. In short, the gain in efficiency may be offset (from producer standpoint) by failure to fully exploit product values.

[5] It should be clear that the increased efficiency induced by these incentives would, among other things, increase the net value of the milk in the production area by selecting the optimum use and by minimizing aggregate transfer cost. It would be possible, of course, to provide incentives of such magnitude that the amount "given away" to handlers could exceed the net gain by cost reduction. Therefore, these incentives will need to be calibrated so as to accomplish the desired objective without at the same time dissipating the benefits to be derived.

5. Except for discrepancies resulting from errors and imperfections of knowledge, the efficient utilization pattern for a milkshed would be achieved if the total market supplies were under the management of a single agency, dedicated, within the restraints of the established class prices, to maximizing returns to the raw product. In most situations, it would be unrealistic to consider consolidating all country facilities under a single firm. Nevertheless this general idea may have some application in the operation of a market. For example, the market administrator might assign utilization quotas for the several products to each plant, making these consistent with the efficiency model.

Some Comments on the New York Study

The Use of Efficiency Models

This paper was written to summarize principles developed and used in the conduct of parts of the present study of the New York milk market. Specifically, the theoretical models provide a framework for the organization of empirical research work. By discussing the attributes of efficiency models, we point to various types of information essential to the empirical study of this market and its operation. Major focus is on decision making by individual firms, for this is the mechanism that activates the whole market. From the theory, it is clear that specific information is needed on such items as product prices at the metropolitan market, processing costs for the various products and joint products in the milkshed, transfer costs, and past and present patterns of actual utilization by product, location, and season.

With these data and the efficiency models, the market can be "programmed" to indicate the optimum situation and changes in this optimum through time. By contrasting these synthetic results with actual utilization patterns, it is possible to judge the operating efficiency of the whole market. These comparisons can be made specific in terms of savings in costs and increases in net values that could result from efficient operation. Moreover, specific subphases of the research can appraise the efficiency of such operations as the combination of ingredients in an optimum or low-cost ice cream mix—and so provide useful management guides to operating firms.

By adding the specific provisions of the classified pricing system to the efficiency model, and relating it to the actual distribution of plants and facilities, a modified short-run efficiency model results. This should more nearly resemble the actual situation, although discrepancies are still to be expected. The model would be especially useful in checking the effects of changes in product prices, cost rates and allowances, and classified prices on the market, and on its aggregate efficiency. Note also that this model can be applied to the operation of any actual firm—taking as given its total utilization pattern and its endownment of plants and facilities, and checking optimum utilization. Again, results may indicate inefficiencies but it is expected that its application will be of more value in indicating the impact of classified prices and other factors on the firm decision making.

Finally, these research results can be combined with the results of management interviews to determine as accurately as possible the way in which firms and the market adjust to changing prices, costs, and classified prices of raw product. This should permit a final appraisal of the market, and suggest specific modifications and changes that would improve efficiency.

Secondary and Competing Markets

As an epilogue, we point to the perhaps obvious simplifications of our theoretical models, and the need for elaboration in actual operation. Some of these have been suggested by the addition of a number of products and byproducts, the treating of plant alternatives rather than individual products, and the insertion of more realistic (and more complicated) cost relationships. These represent merely an elaboration of the model, but some aspects are in the nature of major additions. They include the consideration of competition between New York and other major markets, and the relationships between New York and various "upstate" secondary markets completely surrounded by the major milkshed (and now subject to the New York market order).

Our models relate to a single central market with product zones in the milkshed surrounding this market. Alternative utilization thus involves processing costs, prices for products at the major market, and transfer costs from country points to

the major market center. With the addition of other markets—major or secondary—the analysis must be repeated for each market, and alternative market outlets as well as product outlets given specific consideration. The major principles involved remain as we have stated them in the previous pages, but the final complex model describes the efficient organization for an entire region, and the consistent structure of intermarket prices (or shadow prices) and market-product zones.

From the viewpoint of the present study, it seems probable that limitations of time will force major emphasis on the New York metropolitan market. This will be accomplished by accepting the actual geographic pattern of farm production, plants, and plant-to-market shipments, and inquiring as to efficient operation within these given patterns. This is done with the realization that the specific inclusion of such secondary markets as Albany, Syracuse, Buffalo and Rochester, and such major markets as Boston, Philadelphia, and Pittsburgh would no doubt reveal inefficiencies in the present among-market allocations, and yield valuable information about the problem of pricing in competing markets. But so long as this appears to be impracticable in the present study, it seems appropriate to eliminate all shipments to other markets, and to concentrate attention on the remaining volumes pertinent to the New York market. In this connection, it is recognized that many plants within the New York milkshed serve local markets and are not covered by the New York market operation—thus are not included in the market statistics. Thus the elimination of the pool milk that goes to nonmajor markets means that all supplies for these secondary markets are eliminated from consideration.

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Some Economic Aspects of Food Stamp Programs

By Frederick V. Waugh and Howard P. Davis

La meilleur de tous les tarifs serait celui qui ferait payer à ceux qui passent sur une voie de communication un peage proportionnel à l'utilité qu'ils retirent du passage.[1]—Jules Dupuit, 1849.

FROM AN ECONOMIC STANDPOINT, the essential thing about food stamp programs is not that people can buy food with stamps instead of with money. The essential feature of these programs is that low-income people can buy food at reduced prices. The food stamp (or coupon) is simply a convenient mechanism for enabling these families to pay lower prices, and for enabling the Government to make up the difference by a subsidy from the Federal treasury.

Thus, any form of food stamp program (including the program operated in the United States from 1939 to 1943, and also including the pilot programs recently started in eight experimental areas of this country), is essentially a classified price arrangement. In principle, it is something like classified milk prices, where part of the milk is sold as fluid milk at a class I price and the surplus is sold for cream and manufactured dairy products at lower class II and class III prices. Economists often call such arrangements "price discrimination" or "multiple pricing."

The quotation at the beginning of this article, from the French engineer-economist Jules Dupuit, refers to the system of tolls on bridges and highways, as well as to freight rates on railroads. Dupuit advocated a system of classified tolls or charges in which each commodity and each group of persons would pay rates proportional to the "utility they received." This argument is similar to the argument that freight rates, for example, should be based on the "value of service," or to the one that medical bills should be graduated according to "ability to pay."

Multiple prices may be profitable or unprofitable to the producer. They may benefit or harm the consuming public. A few economists have discussed both aspects of this problem. One of the best discussions since Dupuit is that of Robinson.[2] The main principle is illustrated in figure 1. This diagram does not represent the food stamp program exactly. Rather, it shows how a food stamp program would work if it were a simple 2-price arrangement.

Both sides of the diagram assume that a given amount of food is available. Two demand curves are assumed to be known: The demand by medium- and high-income families, and the demand by needy families. In analyzing 2-price arrangements, it is convenient to show the first of these demand curves in the ordinary way, but to reverse the demand curve for needy families— plotting it from right to left instead of from left to right.

If the market were entirely free and competitive, the price would be determined by the intersection of the two demand curves. Assume that this price is low and that the public generally agrees that some program is needed to raise farm

[1] The best system of pricing would be one that requires each user of a bridge, highway, or railroad to pay a charge proportionate to the benefits he gets.

[2] Robinson, Joan, THE ECONOMICS OF IMPERFECT COMPETITION, chapters 15 and 16. Macmillan. London. 1938.

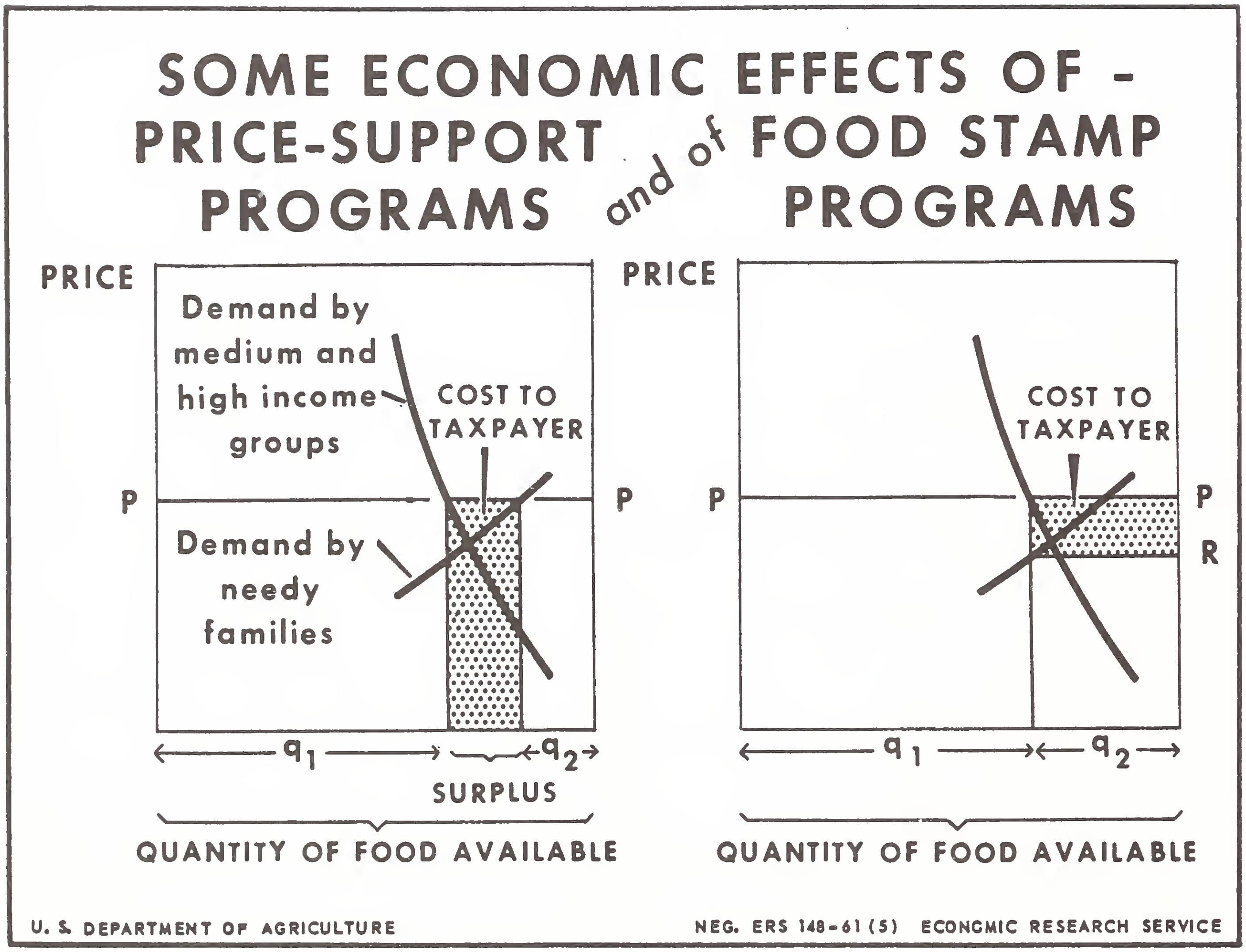

Figure 1.

prices and income. One way of doing this is that shown on the left grid of the diagram. This represents a simple price-support program under which prices are increased to the level marked P. At this price, medium- and high-income groups will buy the quantity marked q_1 and needy families will buy the quantity marked q_2. These two quantities together are less than the amount of food available, leaving the surplus that must be bought by the Government. The cost of this program to the taxpayer is the shaded area marked in the diagram.

The right side of the diagram illustrates what would happen under a simple form of food stamp operation, in which low-income families were allowed to buy as much as they pleased at a discount price. Assume the same level of price support P. But assume that the discount $D=P-R$ is so adjusted that needy families will buy and consume the surplus. The cost to the taxpayer is then the shaded area in the diagram to the right.

The purpose of these two diagrams is not to demonstrate which type of program would cost the taxpayer more. This depends upon the slopes of the two demand curves. We do not yet have an accurate statistical measurement of the demand curve for food by needy families. But in any case some one must pay for any agricultural program that raises farm income. The type of program may determine how these costs are divided between the taxpayer and the consumer of food.

An analysis along the lines shown graphically in the diagram to the right of figure 1 shows that if a producer can divide his market into two parts, one of which is more elastic (or less inelastic)

than the other, he would generally find it profitable to charge a higher price in the less elastic market and a lower price in the more elastic market. The mathematics and geometry presented by Robinson are in terms of marginal returns from the two markets. Assuming that the two markets are independent of one another, and that marginal returns from market 1 are less than from market 2, it will always be profitable to shift part of the supply from market 1 to market 2.

Economists are accustomed to thinking in terms of elasticities of demand rather than in terms of marginal returns. These concepts are closely related. In fact, if MR represents marginal returns, if P represents price, and if e represents elasticity $MR=P\ (1+1/e)$. While economists do not have as much information as they would like about the demand for food by needy families, they have reason to believe that this demand is less inelastic than is the demand for food by medium- and high-income groups.

This means that the marginal returns from food sold in the low-income market are probably greater than the marginal returns from food sold in the medium- and high-income market. For this reason, a good, workable food stamp program would be not only a welfare program to help needy families, it would also be one of the most effective programs—dollar for dollar—for maintaining farm income.

This does not mean that a domestic food stamp program alone would be big enough to handle all surplus problems in agriculture and give farmers a satisfactory income. But it does mean that a dollar spent for a good food stamp program might return as much or more to the farmer than a dollar spent for most other farm programs.

The Present Pilot Food Stamp Programs

Beginning about the first of June, pilot food stamp operations were undertaken in eight areas of the country: Franklin County, Ill.; Floyd County, Ky.; Detroit, Mich.; the Virginia-Hibbing-Nashwauk area of Minnesota; Silver Bow County, Mont.; San Miguel County, N. Mex.; Fayette County, Pa.; and McDowell County, W. Va. These are the "distressed areas" where there are substantial amounts of unemployment and many families receive low incomes.

In these areas, State and local welfare agencies have certified needy families for participation in the stamp program whose incomes are so low that they are unable to afford the cost of an adequate diet. Families with no income get food stamps free of cost, but these families constitute a small proportion of the total number participating. Most families have some income. Those families choosing to participate are charged varying amounts for food coupons, with the charge graduated according to their incomes. The program is entirely voluntary.

If a family chooses to participate, it must buy enough coupons to provide an improved diet. The family uses these coupons to buy food in local retail stores. The participation of retail stores is also voluntary. If a store wants to participate, the owner must apply for permission and be approved. Participating stores receive the food coupons from needy families and cash them at face value at their local banks.

For the present, these pilot programs are limited to the eight areas mentioned. The program will be much too small to have any noticeable effect on the country as a whole. These pilot operations are intended to determine whether it would be feasible to develop a national food stamp program that might eventually raise the nutritional levels of the Nation and redirect our agricultural productive capacity into foods for which there is a greater current need. Without in any way prejudging what these pilot operations may show, it is appropriate at the start to consider how food stamp programs may affect various groups of people, including low-income consumers, food trades, taxpayers, and farmers.

Low-Income Consumers

The pilot stamp programs will enable needy families in the eight areas to buy more nearly adequate, balanced diets. They will not compel them to buy these diets unless needy families choose to do so, but they will give them enough food purchasing power to do so if they choose. The extent to which participating families improve their diets will depend in some degree upon the success of educational efforts to help them spend their food coupons as wisely as possible.

The direct distribution programs that we have had in the past did not pretend to enable low-

income families to get adequate diets. They were much too small for this purpose, and they were restricted to a few foods—in many instances not the foods most needed to improve the diets of low-income families.

The other main feature of the pilot food stamp program is that it gives needy families practically free choice as to the foods they buy with their coupons. The present regulations governing the pilot operations define "eligible foods" to mean "any food or food product for human consumption, except coffee, tea, cocoa (as such), alcoholic beverages, tobacco, and those products which are clearly identifiable from the package as being imported from foreign sources."

At first, many officials in the U.S. Department of Agriculture thought it might be necessary to limit the use of coupons to certain listed foods, or to post in each store a list of ineligible foods. From an administrative standpoint, this would have been a complicated procedure.

The former food stamp program, which operated from 1939 through 1943, used stamps of two different colors. The orange-colored stamps (which were bought by the participating families) could be used to buy any food. The blue stamps (which were paid for by the Government) could be used only to buy foods designated as in surplus.

In principle, the idea of two colors of stamps has a great deal of appeal. But actually, the blue stamps were never very effective in concentrating the additional purchases on surplus items. This was true because the families substituted the "blue stamp" purchases for their normal purchases of these items, and essentially their increased purchasing power resulted in increased total purchases of those items for which they had a greater need.

This might have been different if the "surplus list" had been limited to a very few commodities for which the families had a greater need. And it might have been different if the "surplus list" had been limited to a very few commodities for which the families had real urgent need.

What commodities will benefit under one color of stamp remains to be demonstrated. It is one of the principal things being tested in the pilot operation. From an administrative standpoint, it is easier to operate a program with coupons of one color than with those of two or more colors. Moreover, from the standpoint of the needy families, it is desirable to have as much freedom of choice as possible. Professional welfare experts are generally agreed that "relief in kind" is less desirable than a relief payment in money. The use of food coupons is restricted to foods, but obviously it gives families a greater choice than direct distribution under which they take whatever foods are handed out.

Despite the benefits we have enumerated, some needy families may prefer direct distribution to a food stamp program. Under the direct distribution program, eligible families get a certain quantity of free food without regard to the normal food expenditures for their income group. They can, therefore, divert varying amounts of their previous food expenditures to other nonfood needs. If they participate in a stamp program, they must pay an amount roughly equal to the normal food expenditures of their income group. The Department will carry on an intensive research program during the test period in the pilot areas. Part of this research will deal with consumer attitudes and preferences.

Food Trades

From the standpoint of the food trades, the main feature of the stamp program is that it is operated by and through private industry. The Government does not buy surplus foods and distribute them to needy families in competition with commercial food distribution; it simply enables needy families to buy foods in their local retail stores. The private food trades do all the buying, processing, and distributing. The program will provide a net increase in food sales.

On the other hand, any food stamp program involves some inconvenience and cost to the food trade. Perhaps the managers of stores have become accustomed to such inconvenience as trading stamps and various kinds of coupons under special advertising deals. The food stamp program is voluntary, but present indications are that all retailers will be glad to take part.

Taxpayers

As previously indicated, someone pays for any program that raises farm incomes. But there may be some misunderstanding as to the relative costs of stamp programs and direct distribution.

A fully adequate national food stamp program would probably be fairly expensive. Certainly,

it would cost substantially more than the inadequate direct distribution program we have had in recent years. In a sense, the reason direct distribution programs have generally been felt to have cost practically nothing is because we have simply given away food surpluses that were already owned by the Commodity Credit Corporation.

Recently, the direct distribution program has been substantially increased by adding meat and a number of other vegetable protein foods. If the direct distribution program were expanded until it provided adequate diets, it might well cost more than a food stamp program. This is because it is doubtful that Government distribution can be accomplished for a relatively small number of persons as effectively or as cheaply as our highly developed commercial food-distribution system, which serves the total population.

One of the main purposes of research planned as a part of the pilot program is to make an accurate and reliable appraisal of cost in relation to dollar amounts, as well as kinds, of increased food consumption.

Farmers

Some critics of food stamp programs emphasize that they will not help the main surplus commodities such as wheat, feed grains, and cotton. This is correct. The benefits of food stamp programs will probably be concentrated largely on meats, poultry and eggs, dairy products, and fruits and vegetables. Indirectly, they can be of substantial assistance to corn and other feed grains. In other words, the farm products that these programs will help most are the nonbasic perishable commodities. These are the commodities that Section 32 (an Act to increase the domestic consumption of non-price support, perishable commodities) was designed to assist. The pilot stamp program is being financed from Section 32 funds.

Although food stamp programs will probably never do much to help wheat and cotton, they could, if extended to all needy families throughout the Nation, help to meet the general problem of overcapacity in agriculture. This is not to say that any domestic food program alone is likely to be big enough to prevent surplus problems in the future. We will need many different kinds of programs, including export programs and some means of adjusting production.

But if the pilot operations show us how to develop a workable and effective food stamp program, such a program can be of substantial benefit to farmers in the future.

A Short History of Price Support and Adjustment Legislation and Programs for Agriculture, 1933-65

By Wayne D. Rasmussen and Gladys L. Baker

MANY PROGRAMS of the U.S. Department of Agriculture, particularly those concerned with supporting the prices of farm products and encouraging farmers to adjust production to demand, are the result of a series of interrelated laws passed by the Congress from 1933 to 1965. This review attempts to provide an overall view of this legislation and programs, showing how Congress has modified the legislation to meet changing economic situations, and giving a historical background on program development. It should serve as background for economists and others concerned with analyzing present farm programs.

The unprecedented economic crisis which paralyzed the Nation by 1933 struck first and hardest at the farm sector of the economy. Realized net income of farm operators in 1932 was less than one-third of what it had been in 1929. Farm prices fell more than 50 percent, while prices of goods and services farmers had to buy declined 32 percent. The relative decline in the farmers' position had begun in the summer of 1920. Thus, farmers were caught in a serious squeeze between the prices they received and the prices they had to pay.

Farm journals and farm organizations had, since the 1920's, been advising farmers to control production on a voluntary basis. Attempts were made in some areas to organize crop withholding movements on the theory that speculative manipulation was the cause of price declines. When these attempts proved unsuccessful, farmers turned to the more formal organization of cooperative marketing associations as a remedy. The Agricultural Marketing Act of 1929, establishing the Federal Farm Board, had been enacted on the theory that cooperative marketing organizations aided by the Federal Government could provide a solution to the problem of low farm prices. To supplement this method the Board was also given authority to make loans to stabilization corporations for the purpose of controlling any surplus through purchase operations. By June 30, 1932, the Federal Farm Board stated that its efforts to stem the disastrous decline in farm prices had failed. In a special report to Congress in December 1932, the Board recommended legislation which would "provide an effective system for regulating acreage or quantities sold, or both." The Board's recommendation on control of acreage or marketing was a step toward the development of a production control program.

Following the election of President Franklin D. Roosevelt, who had committed himself to direct Government action to solve the farm crisis, control of agricultural production became the primary tool for raising the prices and incomes of farm people.

The Agricultural Adjustment Act of 1933

The Agricultural Adjustment Act was approved on May 12, 1933. Its goal of restoring farm purchasing power of agricultural commodities to the prewar 1909-14 level was to be accomplished through the use, by the Secretary of Agriculture, of a number of methods. These included the authorization (1) to secure voluntary reduction of the acreage in basic crops through agreements with producers and use of direct payments for participation in acreage control programs; (2) to regulate marketing through voluntary agreements with processors, associations of producers, and other handlers of agricultural commodities or products; (3) to license processors, associations of producers, and others handling agricultural commodities to eliminate unfair practices or charges; (4) to

determine the necessity for and the rate of processing taxes; and (5) to use the proceeds of taxes and appropriate funds for the cost of adjustment operations, for the expansion of markets, and for the removal of agricultural surpluses. Congress declared its intent, at the same time, to protect the consumers' interest. Wheat, cotton, field corn, hogs, rice, tobacco, and milk and its products were designated as basic commodities in the original legislation. Subsequent amendments in 1934 and 1935 expanded the list of basic commodities to include the following: rye, flax, barley, grain sorghums, cattle, peanuts, sugar beets, sugarcane, and potatoes. However, acreage allotment programs were only in operation for cotton, field corn, peanuts, rice, sugar, tobacco, and wheat.

The acreage reduction programs, with their goal of raising farm prices toward parity (the relationship between farm prices and costs which prevailed in 1909-14), could not become effective until the 1933 crops were ready for market. As an emergency measure during 1933, programs for plowing under portions of planted cotton and tobacco were undertaken. The serious financial condition of cotton and corn-hog producers led to demands in the fall of 1933 for price fixing at or near parity levels. The Government responded with nonrecourse loans for cotton and corn. The loans were initiated as temporary measures to give farmers in advance some of the benefits to be derived from controlled production and to stimulate farm purchasing power as a part of the overall recovery program. The level of the first cotton loan, in 1933, at 10 cents a pound, was at approximately 69 percent of parity. The level of the first corn loan, at 45 cents per bushel, was at approximately 60 percent of parity. The loans were made possible by the establishment of the Commodity Credit Corporation on October 17, 1933, by Executive Order 6340. The funds were secured from an allocation authorized by the National Industrial Recovery Act and the Fourth Deficiency Appropriation Act.

The Bankhead Cotton Control Act of April 21, 1934, and the Kerr Tobacco Control Act of June 28, 1934, introduced a system of marketing quotas by allotting to producers quotas of tax-exemption certificates and tax-payment warrants which could be used to pay sales taxes imposed by these acts. This was equivalent to allotting producers the quantities they could market without being taxed. These laws were designed to prevent growers who did not participate in the acreage reduction program from sharing in its financial benefits. These measures introduced the mandatory use of referendums by requiring that two-thirds of the producers of cotton, or growers controlling three-fourths of the acreage of tobacco, had to vote for a continuation of each program if it was to be in effect after the first year of operation.

Surplus disposal programs of the Department of Agriculture were initiated as an emergency supplement to the crop control programs. The Federal Surplus Relief Corporation, later named the Federal Surplus Commodities Corporation, was established on October 4, 1933, as an operating agency for carrying out cooperative food purchase and distribution projects of the Department and the Federal Emergency Relief Administration. Processing tax funds were used to process heavy pigs and sows slaughtered during the emergency purchase program, which was part of the corn-hog reduction campaign begun during November 1933. The pork products were distributed to unemployed families. During 1934 and early 1935, meat from animals purchased with special drought funds was also turned over for relief distribution. Other food products purchased for surplus removal and distribution in relief channels included butter, cheese, and flour. Section 32 of the amendments of August 24, 1935, to the Agricultural Adjustment Act set aside 30 percent of the customs receipts for the removal of surplus farm products.

Production control programs were supplemented by marketing agreement programs for a number of fruits and vegetables and for some other nonbasic commodities. The first such agreement, covering the handling of fluid milk in the Chicago market, became effective August 1, 1933. Marketing agreements raised producer prices by controlling the timing and the volume of the commodity marketed. Marketing agreements were in effect for a number of fluid milk areas. They were also in operation for a short period for the basic commodities of tobacco and rice, and for peanuts before their designation as a basic commodity.

On August 24, 1935, amendments to the Agricultural Adjustment Act authorized the substitution of orders issued by the Secretary of

Agriculture, with or without marketing agreements, for agreements and licenses.

The agricultural adjustment program was brought to an abrupt halt on January 6, 1936, by the Hoosac Mills decision of the Supreme Court, which invalidated the production control provisions of the Agricultural Adjustment Act of May 12, 1933.

Farmers had enjoyed a striking increase in farm income during the period the Agricultural Adjustment Act had been in effect. Farm income in 1935 was more than 50 percent higher than farm income during 1932, due in part to the farm programs. Rental and benefit payments contributed about 25 percent of the amount by which the average cash farm income in 1933-35 exceeded the average cash farm income in 1932.

The Soil Conservation and Domestic Allotment Act of 1936

The Supreme Court's ruling against the production control provisions of the Agricultural Adjustment Act presented the Congress and the Department with the problem of finding a new approach before the spring planting season. Department officials and spokesmen for farmers recommended to Congress that farmers be paid for voluntarily shifting acreage from soil-depleting surplus crops into soil-conserving legumes and grasses. The Soil Conservation and Domestic Allotment Act was approved on February 29, 1936. This Act combined the objective of promoting soil conservation and profitable use of agricultural resources with that of reestablishing and maintaining farm income at fair levels. The goal of income parity, as distinguished from price parity, was introduced into legislation for the first time. It was defined as the ratio of purchasing power of the net income per person on farms to that of the income per person not on farms which prevailed during August 1909-July 1914.

President Roosevelt stated as a third major objective "the protection of consumers by assuring adequate supplies of food and fibre." Under a program launched on March 20, 1936, farmers were offered soil-conserving payments for shifting acreage from soil-depleting crops to soil-conserving crops. Soil-building payments for seeding soil-building crops on cropland and for carrying out approved soil-building practices on cropland or pasture were also offered.

Curtailment in crop production due to a severe drought in 1936 tended to obscure the fact that planted acreage of the crops which had been classified as basic increased despite the soil conservation program. The recurrence of normal weather, crop surpluses, and declining farm prices in 1937 focused attention on the failure of the conservation program to bring about crop reduction as a byproduct of better land utilization.

Agricultural Adjustment Act of 1938

Department officials and spokesmen for farm organizations began working on plans for new legislation to supplement the Soil Conservation and Domestic Allotment Act. The Agricultural Adjustment Act of 1938, approved February 6, 1938, combined the conservation program of the 1936 legislation with new features designed to meet drought emergencies as well as price and income crises resulting from surplus production. Marketing control was substituted for direct production control, and authority was based on Congressional power to regulate interstate and foreign commerce. The new features of the legislation included mandatory nonrecourse loans for cooperating producers of corn, wheat, and cotton under certain supply and price conditions--if marketing quotas had not been rejected--and loans at the option of the Secretary of Agriculture for producers of other commodities; marketing quotas to be proclaimed for corn, cotton, rice, tobacco, and wheat when supplies reached certain levels; referendums to determine whether the marketing quotas proclaimed by the Secretary should be put into effect; crop insurance for wheat; and parity payments, if funds were appropriated, to producers of corn, cotton, rice, tobacco, and wheat in amounts which would provide a return as nearly equal to parity as the available funds would permit. These payments were to supplement and not replace other payments. In addition to payments authorized under the continued Soil Conservation and Domestic Allotment Act for farmers in all areas, special payments were made in 10 States to farmers who cooperated in a program to retire land unsuited to cultivation as part of a restoration land program initiated

in 1938. The attainment, insofar as practicable, of parity prices and parity income was stated as a goal of the legislation. Another goal was the protection of consumers by the maintenance of adequate reserves of food and fiber. Systematic storage of supplies made possible by nonrecourse loans was the basis for the Department's Ever-Normal Granary plan.

Department officials moved quickly to activate the new legislation to avert another depression which was threatening to engulf agriculture and other economic sectors in the Nation. Acreage allotments were in effect for corn and cotton harvested in 1938. The legislation was too late for acreage allotments to be effective for wheat harvested in 1938, because most of this wheat had been seeded in the fall of 1937. Wheat allotments were used only for calculating benefit payments. Marketing quotas were in effect during 1938 for cotton and for flue-cured, burley, and dark tobaccos. Marketing quotas could not be applied to wheat since the Act prohibited their use during the 1938-39 marketing year, unless funds for parity payments had been appropriated prior to May 15, 1938. Supplies of corn were under the level which required proclamation of marketing quotas.

The agricultural adjustment program became fully operative in the 1939-40 marketing year, when crop allotments were available to all farmers before planting time. Commodity loans were available in time for most producers to take advantage of them.

On cotton and wheat loans, the Secretary had discretion in determining the rate at a level between 52 and 75 percent of parity. A loan program was mandatory for these crops if prices fell below 52 percent of parity at the end of the crop year, or if production was in excess of a normal year's domestic consumption and exports. A more complex formula regulated corn loans with the rate graduated in relation to the expected supply, and with 75 percent of parity loans available when production was at or below normal as defined in the Act. Loans for commodities other than corn, cotton, and wheat were authorized, but their use was left to the Secretary's discretion.

Parity payments were made to the producers of cotton, corn, wheat, and rice who cooperated in the program. They were not made to tobacco producers under the 1939 and 1940 programs because tobacco prices exceeded 75 percent of parity. Appropriation language prohibited parity payments in this situation.

Although marketing quotas were proclaimed for cotton and rice, and for flue-cured, burley, and dark air-cured tobacco for the 1939-40 marketing year, only cotton quotas became effective. More than a third of the rice and tobacco producers participating in the referendums voted against quotas.

Without marketing quotas, flue-cured tobacco growers produced a recordbreaking crop and, at the same time, the growers faced a sharp reduction in foreign markets due to the withdrawal of British buyers about 5 weeks after the markets opened. The loss of outlets caused a shutdown in the flue-cured tobacco market. During the crisis period, growers approved marketing quotas for their 1940-41 crop, and the Commodity Credit Corporation, through a purchase and loan agreement, restored buying power to the market.

In addition to tobacco, marketing quotas were in effect for the 1941 crops of cotton, wheat, and peanuts. Marketing quotas for peanuts had been authorized by legislation approved on April 3, 1941.

Acreage allotments for corn and acreage allotments and marketing quotas for cotton, tobacco, and wheat reduced the acreage planted during the years they were in effect. For example, the acreage of wheat seeded dropped from a high of almost 81 million acres in 1937 to around 63 million in 1938; it remained below 62 million acres until 1944. Success in controlling acreage, which was most marked in the case of cotton, where marketing quotas were in effect every year until July 10, 1943, and where long-run adjustments were taking place, was not accompanied by a comparable decline in production. Yield per harvested acre began an upward trend for all four crops. The trend was most marked for corn, due largely to the use of hybrid seed.

High farm production after 1937, at a time when nonfarm income remained below 1937 levels, resulted in a decline in farm prices of approximately 20 percent from 1938 through 1940. The nonrecourse loans and payments helped to prevent a more drastic decline in farm income. Direct Government payments

reached their highest levels in 1939 when they were 35 percent of net cash income received from sales of crops and livestock. They were 30 percent in 1940, but fell to 13 percent in 1941 when farm prices and incomes began their ascent in response to the war economy.

In the meantime, the Department had been developing new programs to dispose of surplus food and to raise the nutritional level of low-income consumers. The direct distribution program, which began with the distribution of surplus pork in 1933, was supplemented by a nationwide school lunch program, a low-cost milk program, and a food stamp program. The number of schools participating in the school lunch program reached 66,783 during 1941. The food stamp program, which reached almost 4 million people in 1941, was discontinued on March 1, 1943 because of the wartime development of food shortages and relatively full employment.

Wartime Measures

The large stocks of wheat, cotton, and corn resulting from price-supporting loans, which had caused criticism of the Ever-Normal Granary, became a military reserve of crucial importance after the United States entered World War II. Concern over the need to reduce the buildup of Government stocks--a task complicated by legislative barriers such as the minimum national allotment of 55 million acres for wheat, the restrictions on sale of stocks of the Commodity Credit Corporation, and the legislative definition of farm marketing quotas as the actual production or normal production on allotted acreage--changed during the war and postwar period to concern about attainment of production to meet war and postwar needs.

On December 26, 1940, the Department asked farmers to revise plans and to have at least as many sows farrowing in 1941 as in 1940. Following the passage of the Lend-Lease Act on March 11, 1941, Secretary of Agriculture Claude R. Wickard announced, on April 3, 1941, a price support program for hogs, dairy products, chickens, and eggs at a rate above market prices. Hogs were to be supported at not less than $9 per hundredweight.

Congress decided that legislation was needed to insure that farmers shared in the profits which defense contracts were bringing to the American economy and as an incentive to wartime production. It passed legislation, approved on May 26, 1941, to raise the loan rates of cotton, corn, wheat, rice, and tobacco, for which producers had not disapproved marketing quotas, up to 85 percent of parity. The loan rates were available on the 1941 crop and were later extended to subsequent crops of cotton, corn, wheat, peanuts, rice, and tobacco.

Legislation raising the loan rates for basic commodities was followed by the "Steagall Amendment" on July 1, 1941. This Amendment directed the Secretary to support at not less than 85 percent of parity the prices of those nonbasic commodities for which he found it necessary to ask for an increase in production.

The rate of support was raised to not less than 90 percent of parity for corn, cotton, peanuts, rice, tobacco, and wheat, and for the Steagall nonbasic commodities, by a law approved on October 2, 1942. However, the rate of 85 percent of parity could be used for any commodity if the President should determine the lower rate was required to prevent an increase in the cost of feed for livestock and poultry and in the interest of national defense. This determination was made for wheat, corn, and rice. Since the price of rice was above the price support level, loans were not made.

The legislation of October 2, 1942, raised the price support level to 90 percent of parity for the nonbasic commodities for which an increase in production was requested. The following were entitled to 90 percent of parity by the Steagall Amendment: manufacturing milk, butterfat, chickens, eggs, turkeys, hogs, dry peas, dry beans, soybeans for oil, flaxseed for oil, peanuts for oil, American Egyptian cotton, Irish potatoes, and sweetpotatoes.

The price support rate for cotton was raised to 92 1/2 percent of parity and that for corn, rice, and wheat was set at 90 percent of parity by a law approved on June 30, 1944. Since the price of rice was far above the support level for rice, loan rates were not announced. The Surplus Property Act of October 3, 1944 raised the price support rate for cotton to 95 percent of parity with respect to crops harvested after December 31, 1943 and those planted in 1944. Cotton was purchased by the Commodity Credit

Corporation at the rate of 100 percent of parity during 1944 and 1945.

In addition to price support incentives for the production of crops needed for lend-lease and for military use, the Department gradually relaxed penalties for exceeding acreage allotments, provided the excess acreage was planted to war crops. In some areas during 1943, deductions were made in adjustment payments for failure to plant at least 90 percent of special war crop goals. Marketing quotas were retained throughout the war period on burley and flue-cured tobacco to encourage production of crops needed for the war. Marketing quotas were retained on wheat until February 1943. With the discontinuance of marketing quotas, farmers in spring wheat areas were urged to increase wheat plantings whenever the increase would not interfere with more vital war crops. Quotas were retained on cotton until July 10, 1943, and on fire-cured and dark air-cured tobacco until August 14, 1943. With controls removed, the adjustment machinery was used to secure increased production for war requirements and for postwar needs of people abroad who had suffered war's destruction.

Postwar Price Supports

With wartime price supports scheduled to expire on December 31, 1948, price support levels for basic commodities would drop back to a range of 52 to 75 percent of parity as provided in the Agricultural Adjustment Act of 1938, with only discretionary support for nonbasic commodities. Congress decided that new legislation was needed, and the Agricultural Act of 1948, which also contained amendments to the Agricultural Adjustment Act of 1938, was approved on July 3, 1948. The Act provided mandatory price support at 90 percent of parity for the 1949 crops of wheat, corn, rice, peanuts marketed as nuts, cotton, and tobacco marketed before June 30, 1950, if producers had not disapproved marketing quotas. Mandatory price support at 90 percent of parity or comparable price was also provided for Irish potatoes harvested before January 1, 1949; hogs; chickens over 3 1/2 pounds live weight; eggs; and milk and its products through December 31, 1949. Price support was provided for edible dry beans, edible dry peas, turkeys, soybeans for oil, flaxseed for oil, peanuts for oil, American Egyptian cotton, and sweetpotatoes through December 31, 1949, at not less than 60 percent of parity or comparable price nor higher than the level at which the commodity was supported in 1948. The Act authorized the Secretary of Agriculture to require compliance with production goals and marketing regulations as a condition of eligibility for price support to producers of all nonbasic commodities marketed in 1949. Price support for wool marketed before June 30, 1950, was authorized at the 1946 price support level, an average price to farmers of 42.3 cents per pound. Price support was authorized for other commodities through December 31, 1949, at a fair relationship with other commodities receiving support, if funds were available.

The parity formula was revised to make the pattern of relationships among parity prices dependent upon the pattern of relationships of the market prices of such commodities during the most recent moving 10-year period. This revision was made to adjust for changes in productivity and other factors which had occurred since the base period 1909-14.

Title II of the Agricultural Act of 1948 would have provided a sliding scale of price support for the basic commodities (with the exception of tobacco) when quotas were in force but it never became effective. The Act of 1948 was superseded by the Agricultural Act of 1949 on October 31, 1949.

The 1949 Act set support prices for basic commodities at 90 percent of parity for 1950 and between 80 percent and 90 percent for 1951 crops, if producers had not disapproved marketing quotas or (except for tobacco) if acreage allotments or marketing quotas were in effect. For tobacco, price support was to continue after 1950 at 90 percent of parity if marketing quotas were in effect. For the 1952 and succeeding crops cooperating producers of basic commodities--if they had not disapproved marketing quotas--were to receive support prices at levels varying from 75 to 90 percent of parity, depending upon the supply.

Price support for wool, mohair, tung nuts, honey, and Irish potatoes was mandatory at levels ranging from 60 to 90 percent of parity. Whole milk and butterfat and their products were to be supported at the level between 75

and 90 percent of parity which would assure an adequate supply. Wool was to be supported at such level between 60 and 90 percent of parity as was necessary to encourage an annual production of 360 million pounds of shorn wool.

Price support was authorized for any other nonbasic commodity at any level up to 90 percent of parity, depending upon the availability of funds and other specified factors, such as perishability of the commodity and ability and willingness of producers to keep supplies in line with demand.

Prices of any agricultural commodity could be supported at a level higher than 90 percent of parity if the Secretary determined, after a public hearing, that the higher price support level was necessary to prevent or alleviate a shortage in commodities essential to national welfare, or to increase or maintain production of a commodity in the interest of national security.

The Act amended the modernized parity formula of the Agricultural Act of 1948 to add wages paid hired farm labor to the parity index and to include wartime payments made to producers in the prices of commodities and in the index of prices received. For basic commodities, the effective parity price through 1954 was to be the "old" or the "modernized," whichever was higher. For many nonbasic commodities, the modernized parity price became effective in 1950. However, parity prices for individual commodities under the modernized formula, provided in the Act of 1948, were not to drop more than 5 percent a year from what they would have been under the old formula.

The Act provided for loans to cooperatives for the construction of storage facilities and for certain changes with respect to acreage allotment and marketing quota provisions, and directed that Section 32 funds be used principally for perishable, nonbasic commodities. The Act added some new provisions on the sale of commodities held by the Commodity Credit Corporation. Prices were to be supported by loans, purchases, or other operations.

Under authority of the Agricultural Act of 1949, price support for basic commodities was maintained at 90 percent of parity through 1950. Supports for nonbasic commodities were generally at lower levels during 1949 and 1950 than in 1948 whenever this was permitted by law. Price supports for hogs, chickens, turkeys, long-staple cotton, dry edible peas, and sweetpotatoes were discontinued in 1950.

The Korean War

The flexible price support provisions of the Agricultural Act of 1949 were used for only one basic commodity during 1951. Secretary Charles F. Brannan used the national security provision of the Act to keep price support levels at 90 percent of parity for all of the basic commodities except peanuts. The price support rate for peanuts was raised to 90 percent for 1952. The outbreak of the Korean War on June 25, 1950, made it necessary for the Department to adjust its programs to secure the production of sufficient food and fiber to meet any eventuality. Neither acreage allotments nor marketing quotas were in effect for the 1951 and 1952 crops of wheat, rice, corn, or cotton. Allotments and quotas were in effect for peanuts and most types of tobacco.

Prices of oats, barley, rye, and grain sorghums were supported at 75 percent of parity in 1951 and 80 percent in 1952. Naval stores, soybeans, cottonseed, and wool were supported both years at 90 percent, while butterfat was increased to 90 percent for the marketing year beginning April 1, 1951. Price support for potatoes was discontinued in 1951 in accordance with a law of March 31, 1950, which prohibited price support on the 1951 and subsequent crops unless marketing quotas were in effect. Congress never authorized the use of marketing quotas for potatoes.

The Korean War strengthened the case of Congressional leaders who did not want flexible price supports to become effective for basic commodities. Legislation of June 30, 1952, to amend and extend the Defense Production Act of 1950 provided that price support loans for basic crops to cooperators should be at the rate of 90 percent of parity, or at higher levels, through April 1953, unless producers disapproved marketing quotas.

The period for mandatory price support at 90 percent of parity for basic commodities was again extended by legislation approved on July 17, 1952. It covered the 1953 and 1954 crops of basic commodities if the producers had not disapproved marketing quotas. This legislation

also extended through 1955 the requirement that the effective parity price for the basic commodities should be the parity price computed under the new or the old formula, whichever was higher. Extra long staple cotton was made a basic commodity for price support purposes.

Levels of Price Support--Fixed or Flexible

The end of the Korean War in 1953 necessitated changes in price support, production control, and related programs. For the next 8 years, controversy over levels of support--high, fixed levels versus a flexible scale--dominated the scene.

Secretary of Agriculture Ezra Taft Benson proclaimed marketing quotas for the 1954 crops of wheat and cotton on June 1, 1953, and October 9, 1953, respectively. The major types of tobacco and peanuts continued under marketing quotas. However, quotas were not imposed on corn. The Secretary announced on February 27, 1953, that dairy prices would be supported at 90 percent of parity for another year beginning April 1, 1953. Supports were continued at 90 percent of parity for basic crops during 1953 and 1954, in accordance with the legislation of July 17, 1952.

The Agricultural Trade Development and Assistance Act, better known as Public Law 480, was approved July 10, 1954. This Act, which served as the basic authority for sale of surplus agricultural commodities for foreign currency, proved to be of major importance in disposing of farm products abroad.

The Agricultural Act of 1954, approved August 28, 1954, established price supports for the basic commodities on a flexible basis, ranging from 82.5 percent of parity to 90 percent for 1955 and from 75 percent to 90 percent thereafter; an exception was tobacco, which was to be supported at 90 percent of parity when marketing quotas were in effect. The transition to flexible supports was to be eased by "set asides" of basic commodities. Not more than specified maximum nor less than specified minimum quantities of these commodities were to be excluded from the "carryover" for the purpose of computing the level of support. Special provisions were added for various commodities. One of the most interesting, under the National Wool Act, required that the price of wool be supported at a level between 60 and 110 percent of parity, with payments to producers authorized as a method of support. This method of support has continued in effect.

The Soil Bank

The Soil Bank, established by the Agricultural Act of 1956, was a large-scale effort, similar in some respects to programs of the 1930's, to bring about adjustments between supply and demand for agricultural products by taking farmland out of production. The program was divided into two parts--an acreage reserve and a conservation reserve. The specific objective of the acreage reserve was to reduce the amount of land planted to allotment crops--wheat, cotton, corn, tobacco, peanuts, and rice. Under its terms, farmers cut land planted to these crops below established allotments, or, in the case of corn, their base acreage, and received payments for the diversion of such acreage to conserving uses. In 1957, 21.4 million acres were in the acreage reserve. The last year of the program was 1958.

All farmers were eligible to participate in the conservation reserve by designating certain crop land for the reserve and putting it to conservation use. A major objection to this plan in some areas was that communities were disrupted when many farmers placed their entire farms in the conservation reserve. On July 15, 1960, 28.6 million acres were under contract in this reserve.

The Agricultural Act of August 28, 1958, made innovations in the cotton and corn support programs. It also provided for continuation of supports for rice, without requiring the exact level of support to be based on supply. Price support for most feed grains became mandatory.

For 1959 and 1960, each cotton farmer was to choose between (a) a regular acreage allotment and price support, or (b) an increase of up to 40 percent in allotment with price support 15 points lower than the percentage of parity set under (a). After 1960, cotton was to be under regular allotments, supported between 70 and 90 percent of parity in 1961 and between 65 and 90 percent after 1961.

Corn farmers, in a referendum to be held not later than December 15, 1958, were given the option of voting either to discontinue acreage

allotments for the 1959 and subsequent crops and to receive supports at 90 percent of the average farm price for the preceding 3 years but not less than 65 percent of parity, or to keep acreage allotments with supports between 75 and 90 percent of parity. The first proposal was adopted for an indefinite period in a referendum held November 25, 1958.

Farm Programs in the 1960's

President John F. Kennedy's first executive order after his inauguration on January 20, 1961, directed Secretary of Agriculture Orville L. Freeman to expand the program of food distribution to needy persons. This was done immediately. A pilot food stamp plan was also started. In addition, steps were taken to expand the school lunch program and to make better use of American agricultural abundance abroad.

The new Administration's first law dealing with agriculture, the Feed Grain Act, was approved March 22, 1961. It provided that the 1961 crop of corn should be supported at not less than 65 percent of parity (the actual rate was 74 percent), and established a special program for diverting corn and grain sorghum acreage to soil-conserving crops or practices. Producers were eligible for price supports only after retiring at least 20 percent of the average acreage devoted to the two crops in 1959 and 1960.

The Agricultural Act of 1961 was approved August 8, 1961. Specific programs were established for the 1962 crops of wheat and feed grains, aimed at diverting acreage from these crops. The Act authorized marketing orders for peanuts, turkeys, cherries and cranberries for canning or freezing, and apples produced in specified States. The National Wool Act of 1954 was extended for 4 years, and Public Law 480 was extended through December 31, 1964.

The Food and Agriculture Act of 1962, signed September 27, 1962, continued the feed grain program for 1963. It provided that price supports would be set by the Secretary between 65 and 90 percent of parity for corn and related prices for other feeds. Producers were required to participate in the acreage diversion as a condition of eligibility for price support.

The Act of 1962 provided supports for the 1963 wheat crop at $1.82 a bushel (83 percent of parity) for farmers complying with existing wheat acreage allotments, and offered additional payments to farmers retiring land from wheat production.

Under the new law beginning in 1964, the 55-million-acre minimum national allotment of wheat acreage was permanently abolished, and the Secretary could set allotments as low as necessary to limit production to the amount needed. Farmers were to decide between two systems of price supports. The first system provided for the payment of penalties by farmers overplanting acreage allotments and provided for issuance of marketing certificates based on the quantity of wheat estimated to be used for domestic human consumption and a portion of the number of bushels estimated for export. The amount of wheat on which farmers received certificates would be supported between 65 and 90 percent of parity; the remaining production would be set at a figure based upon its value as feed. The 15-acre exemption was also to be cut. The second system imposed no penalties for overplanting, but provided that wheat grown by planters complying with allotments would be supported at only 50 percent of parity.

The first alternative was defeated in a referendum held on May 21, 1963, but a law passed early in 1964 kept the second alternative from becoming effective.

On May 20, 1963, another feed grain bill permitted continuation in 1964-65, with modifications, of previous legislation. It provided supports for corn for both years at 65 to 90 percent of parity, and authorized the Secretary to require additional acreage diversion.

The most important farm legislation in 1964 was the Cotton-Wheat Act, approved April 11, 1964. The Secretary of Agriculture was authorized to make subsidy payments to domestic handlers or textile mills in order to bring the price of cotton consumed in the United States down to the export price. Each cotton farm was to have a regular and a domestic cotton allotment for 1964 and 1965. A farmer complying with his regular allotment was to have his crop supported at 30 cents a pound (about 73.6 percent of parity). A farmer complying with his domestic allotment would receive a support price up to 15 percent higher (the actual figure in 1964 was 33.5 cents a pound).

The Cotton-Wheat Act of 1964 set up a voluntary wheat-marketing certificate program for

1964 and 1965, under which farmers who complied with acreage allotments and agreed to participate in a land-diversion program would receive price supports, marketing certificates, and land-diversion payments, while noncompliers would receive no benefits. Wheat food processors and exporters were required to make prior purchases of certificates to cover all the wheat they handled. Price supports, including loans and certificates, for the producer's share of wheat estimated for domestic consumption (in 1964, 45 percent of a complying farmer's normal production) would be set from 65 to 90 percent of parity. The actual figure in 1964 was $2 a bushel, about 79 percent of parity. Price supports, including loans and certificates, on the production equivalent to a portion of estimated exports (in 1964, also 45 percent of the normal production of the farmer's allotment) would be from 0 to 90 percent of parity. The export support price in 1964 was $1.55 a bushel, about 61 percent of parity. The remaining wheat could be supported from 0 to 90 percent of parity; in 1964 the support price was at $1.30, about 52 percent of parity. Generally, price supports through loans and purchases on wheat were at $1.30 per bushel in 1964, around the world market price, while farmers participating in the program received negotiable certificates which the Commodity Credit Corporation agreed to purchase at face value to make up the differences in price for their share of domestic consumption and export wheat. The average national support through loans and purchases on wheat in 1965 was $1.25 per bushel.

The carryover of all wheat on July 1, 1965, totaled 819 million bushels, compared with 901 million bushels in 1964 and 1.3 billion bushels in 1960.

The Food and Agriculture Act of 1965

Programs established by the Food and Agriculture Act of 1965, approved November 3, 1965, are to be in effect from 1966 through 1969. After approval of the plan in referendum, each dairy producer in a milk marketing area is to receive a fluid milk base, thus permitting him to cut his surplus production. The Wool Act of 1954 and the voluntary feed grain program begun in 1961 are extended through 1969.

The market price of cotton is to be supported at 90 percent of estimated world price levels, thus making payments to mills and export subsidies unnecessary. Incomes of cotton farmers are to be maintained through payments based on the extent of their participation in the allotment program, with special provisions for protecting the income of farmers with small cotton acreages. Participation is to be voluntary (although price support eligibility generally depends on participation) with a minimum acreage reduction of 12.5 percent from effective farm allotments required for participation on all but small farms.

The voluntary wheat certificate program begun in 1964 is extended through 1969 with only limited changes. The rice program is to be continued, but an acreage diversion program similar to wheat is to be effective whenever the national acreage allotment for rice is reduced below the 1965 figure.

The Act established a cropland adjustment program. The Secretary is authorized to enter into 5- to 10-year contracts with farmers calling for conversion of cropland into practices or uses which will conserve water, soil, wildlife, or forest resources, or establish or protect or conserve open spaces, national beauty, wildlife or recreational resources, or prevent air or water pollution. Payments are to be not more than 40 percent of the value of the crop that would have been produced on the land. Contracts entered into in each of the next 4 fiscal years may not obligate more than $225 million per calendar year.

The Food and Agriculture Act of 1965, which offers farmers a base for planning for the next 4 years, continues many of the features which have characterized farm legislation since 1933. For a third of a century, price support and adjustment programs have had an important impact upon the farm and national economy. Consumers have consistently had a reliable supply of farm products, but the proportion of consumers' income spent for these products has declined. The legislation and resulting programs have been modified to meet varying conditions of depression, war, and prosperity, and have sought to give farmers, in general, economic equality with other segments of the economy.

A National Model of Agricultural Production Response

By W. Neill Schaller[1]

THE NATIONAL ECONOMIC MODEL described in this paper was developed by the Farm Production Economics Division, Economic Research Service. Many agricultural economists know of this analytical endeavor as the "FPED national model." The research is outlined in only a few published papers--none widely circulated (10, 11, 12)[2]-- and so a more complete and accessible report is overdue.

The developmental research began in 1964. Although the resulting model is now operational, improvements are still being made. Therefore, what follows is an interim report on the methodology used so far, a discussion of tests completed and underway, and a summary of lessons learned from the research experience.

Background

THE PROBLEM

The specific research mission is that of providing short-term quantitative estimates of aggregate production and resource adjustments under alternative prices, costs, technologies, resource supplies, and Government programs. This kind of research might be called "impact analysis" or "what-if" research. One can think of many policy questions requiring this information: What would be the probable acreage of cotton next year if proposed changes are made in the cotton program? How would these changes affect soybean production? How much will a proposed feed grain program cost the Government? What will be the most likely effects of the program on aggregate farm income and resource use?

Answers to such questions have always been provided by area and commodity specialists based on the facts and figures at their disposal. The specialist normally uses what might be called informal methods of analysis. His ability to draw logical inferences from available data and research results, and to season these with informed judgment, is his trademark. The purpose of a formal model is to help the specialist by providing a systematic way of bringing to bear on a research problem more quantitative facts and relationships than the human mind alone can analyze.

It became apparent in the early 1960's that the Division's ability to apply formal research to specific policy issues needed to be amplified. The models then in operation were designed for longer term use and did not yield timely estimates of probable short-run response for the Nation as a whole or for major producing areas and farm types.

Existing research centered on two activities: Participation in regional adjustment studies and analyses of interregional competition. The regional studies, in cooperation with State universities, used linear programming to quantify optimum adjustments on farms of different types.[3]

[1] Credit for the research reported in this article goes to a team of researchers located in Washington and at a number of field stations.

[2] Underscored numbers in parentheses refer to items in the References.

[3] These cooperative studies have titles such as "An Economic Appraisal of Farming Adjustment Opportunities in the __________ Region to Meet Changing Conditions." The different regional projects are known popularly as S-42, W-54, GP-5, the Northeast dairy adjustment study, and the Lake States dairy adjustment study. See (16) and (18) for examples of published research.

The Division's interregional competition research, in cooperation with Iowa State University, was concerned with the longer run question, How would production be allocated among regions under optimum economic adjustments?[4]

THE TASK FORCE

In 1963, a Division task force set out to determine what could be done to strengthen research in this area.[5] We first considered the possibilities of modifying the existing representative farm research program to meet our additional needs. This would have involved (1) modifying the linear programming farm models, or systematically adjusting the solutions, so that the resulting estimates would more nearly represent probable short-term response; and (2) aggregating the results.

One way to modify a linear programming model for shorter-run predictive purposes, discussed again later on, is to use current technical data and to add behavioral or flexibility restraints on enterprise levels. Mighell and Black applied this general approach in their pioneering study of interregional competition (8). The theory of flexibility restraints suggests that actual year-to-year changes in the past are logical data on which to base these upper and lower bounds (2, 5, 13). But because time series data are available for aggregates of farms rather than individual farms, this theory would be difficult to apply at the farm level. Similarly, there was no known way to systematically adjust optimum farm solutions to represent "probable" response.

The problem of obtaining aggregate estimates from representative farm analyses appeared equally difficult. As several hundred of these farms were involved in the regional work, the basic question was whether it is realistic to try to build up national aggregate estimates from the farm level (1, 11, 14).

In view of these difficulties, the task force turned to the possibilities of adapting existing interregional competition models. Here the problems of modifying the model and obtaining aggregate results were less severe because the models were national in scope and used geographic regions as units of analysis. But these models, by design, were concerned only with the longer run equilibrium adjustments between regions, whereas we needed also to provide estimates for farming situations within regions.

In summary, the nature of our existing research pointed definitely to the need for a new, complementary model with two essential characteristics. First, the model must be aggregate in perspective but still retain as much micro detail as possible within practical limits on cost, time, and research manageability. Second, the model must incorporate technical attributes that will give it a much stronger predictive property than is found in most linear programming models.

Other techniques examined by the task force included a number of conventional statistical models and simulation. As statistical models analyze data on actual economic behavior, the resulting estimates are considered more predictive than the solutions to an optimizing model. However, policy questions typically require analyses of effects of production environments that differ substantially from the "structure" observed in the past.

Simulation was thought to be especially promising for our purposes. As defined by most economists, it too involves use of data on actual behavior. Simulation is more versatile than other statistical methods for many policy problems. However, at the time of our evaluation, few agricultural economists had had sufficient experience with simulation.

So, we came back to programming as the method currently best suited to our needs. We did so with the idea that the model would be only a first step--that it would be gradually reshaped to incorporate more desirable properties and that other models would be developed over time to supplement or even replace it.

Characteristics of the Model

With only minor changes, the national model blueprint drawn up in 1964 describes the current framework. The model is based on the cobweb principle that current production depends on

[4] This research project is titled "Economic Appraisal of Regional Adjustments in Agricultural Production and Resource Use to Meet Changing Demand and Technology." See (15) for an example of published results.

[5] Members of the task force were Walter R. Butcher, Chairman (now at Washington State University), Thomas F. Hady, John E. Lee, Jr., and the author.

past prices, while current prices depend upon current production (6, 20, 21).

In its simplest form, the principle is expressed by two equations:

(1) $Q_t = f(P_{t-1})$

(2) $P_t = f(Q_t)$

Empirical applications of the cobweb principle almost always involve use of regression analysis of aggregate time series data on prices and production. The national model, in contrast, is a more elaborate cobweb model that uses recursive linear programming to estimate production (5, 13). To date we have limited our development and testing of the model to the part of the system in which production for year t + 1 is estimated from prices and other data through year t (equation 1). However, the full system is outlined below under "operation of the model."

The current model is primarily a crop production model. The methodology is believed to be less suitable for estimating livestock response. However, livestock are included on a limited scale.

The units of analysis in the model are aggregate producing units. They consists of geographic areas, many of which are further divided into aggregate resource situations. The latter unit is simply an aggregate of farms--not necessarily contiguous farms--having similar production alternatives, resource combinations, and other characteristics. The purpose of this subdivision is to strengthen area estimates, by recognizing major differences among farms within the area, and to enable us to say something about production response on major types of farms.

More often than not, the firm is the unit of analysis in applications of linear programming. When an aggregate of firms is the unit, one is assuming that the firms are sufficiently similar that they will respond in a similar way to economic stimuli.[6] One is not assuming that decisions for each firm are made by a hypothetical master-planner. This distinction seems trivial, but if the latter assumption is made, an incorrect evaluation of results of the model may follow. The real issue is the extent to which the reliability of aggregate model results is reduced as the assumption of firm homogeneity becomes less tenable. This question is discussed under test results.

[6] From a programming standpoint, if the firms meet certain conditions of similarity, the same programming solution is obtained by summing the solutions to individually programmed firms and by solving one firm model with right-hand-side elements equal to the sum of firm right-hand-sides.

METHOD OF ANALYSIS

Each production year is treated by the model as a different decision problem for farmers. Hence a different programming problem with profit maximization as the objective is defined for each year. Of course, a different problem is also specified for each resource situation.

The farmer, when making plans for next year, knows that he cannot influence the prices he pays and receives, nor does he know what yields he will obtain. We assume that he formulates his expectations largely on the basis of recent experience. Accordingly, the price and yield data in the programming problem for each year--the data we assume to represent farmers' expectations--are based on data for the preceding year(s).

The recursive programming model assumes that farmers want to make as much money as possible, but only within realistic and often very restrictive limits. Herein lies an important methodological difference between the traditional use of programming (to determine how resources "ought to be" allocated to maximize profit) and its use in the national model.

As noted earlier, farmers are not likely to maximize profit even if they want to (except by chance) because many of the profit-determining variables are unknown to them when plans are made. Also, farmers seldom choose to respond exactly as the short-run economic "optimum" would dictate. They have interests in addition to immediate profit, such as longer run income considerations, a desire for leisure, and personal preferences for producing certain commodities.

As we want to estimate farmers' most likely production response, the model must take these other economic and noneconomic forces into

account.[7] The technique used so far is to add flexibility restraints on the year-to-year change in the aggregate acreage of each production alternative specified in the model. These limits are expressed as percentage increases and decreases from the previous year's acreage. In programming notation, they are expressed as follows for a given resource situation:

Upper bound: $X_{jt} \leq (1 + \bar{\beta}_j)\ X_{j,\ t-1}$

Lower bound: $X_{jt} \geq (1 - \underline{\beta}_j)\ X_{j,\ t-1}$

where X_{jt} refers to the total solution acreage of crop j for year t; $X_{j,\ t-1}$ is the actual acreage in year t-1 (or our best estimate of that acreage); and $\bar{\beta}_j$ and $\underline{\beta}_j$ are the maximum allowable percentage increase and decrease, respectively (decimal form), from the acreage in the preceding year. For example, if the cotton acreage in year t-1 is 100,000 acres, and $\bar{\beta}$ and $\underline{\beta}$ equal 10 and 40 percent, respectively, the solution acreage of cotton is restrained to fall between 110,000 and 60,000 acres.

Empirically, $\bar{\beta}$ and $\underline{\beta}$ (called flexibility coefficients) can be estimated in many ways, ranging from use of the average percentage changes in the recent past to application of a more comprehensive regression analysis.[8] The basic principle followed in almost all cases is that acreage history measures indirectly the many forces that have kept the particular enterprise from increasing or declining at a faster rate. Often, however, it is desirable to adjust the results of the historical analysis to account for information about the current production environment (for example, a new technology, market competitor, or change in Government supply programs for the enterprise or its alternatives.)

Apart from the explicit treatment of time and the addition of flexibility restraints, the programming problem for each resource situation--the programming submodel--is quite like a conventional programming model applied to an aggregate unit. The "objective" of each submodel is to maximize total net returns over variable costs. The activities in the submodel are the production alternatives and other choices open to the unit. The restraints include cropland, other physical resource limitations, and institutional limits such as allotments.

OPERATION OF THE MODEL

The cobweb or recursive principle of economic behavior fits crop agriculture better than any other industry. This is because of the relatively large number of producing units and the biologically imposed time lag in the production of farm crops. Thus it is reasonable to assume that farmers will act independently when making production plans for the period ahead and that aggregate acreage and price information received during the production period will not affect actual production as much as it often does in other industries. Livestock response is more complex. Hence the current model, as mentioned earlier, is primarily a crop model.

The cobweb principle applied to crops permits us to analyze response sequentially--the way it occurs. To estimate national response 1 year ahead (1) almost any producing unit--from the single farm to a broad geographic area--can be analyzed as an independent part of the whole, and (2) we can say with relative confidence that the sum of independent plans will be a reasonable estimate of aggregate output.

When aggregate estimates are to be made for more than a year ahead (or if income next year is to be estimated), the price effects of aggregate output in the first year must be taken into account. But this can be done as a separate step in the analytical sequence.

Short-run analysis (1 year ahead): The 1-year analysis is illustrated schematically in figure 1. In the case of each crop, the unknown variable estimated by the model is "planned" acreage. As in most models of this type, no attempt is

[7] Admittedly, there are different interpretations of this problem. Tweeten writes that "...farmers need not maximize profit for the programming models to predict actual behavior--it is only necessary that farmers behave as if they were following the profit-maximizing norm subsumed in the programming models" (19, p. 95).

[8] In addition to using time series analysis of actual data to estimate bounds, an analysis of the discrepancies between optimum and actual response might also prove useful. One can see that with flexibility restraints derived from some kind of time series analysis, the model becomes a synthesis of what the profession calls "positive" and "normative" research.

RECURSIVE ANALYSIS OF PRODUCTION AND RESOURCE USE

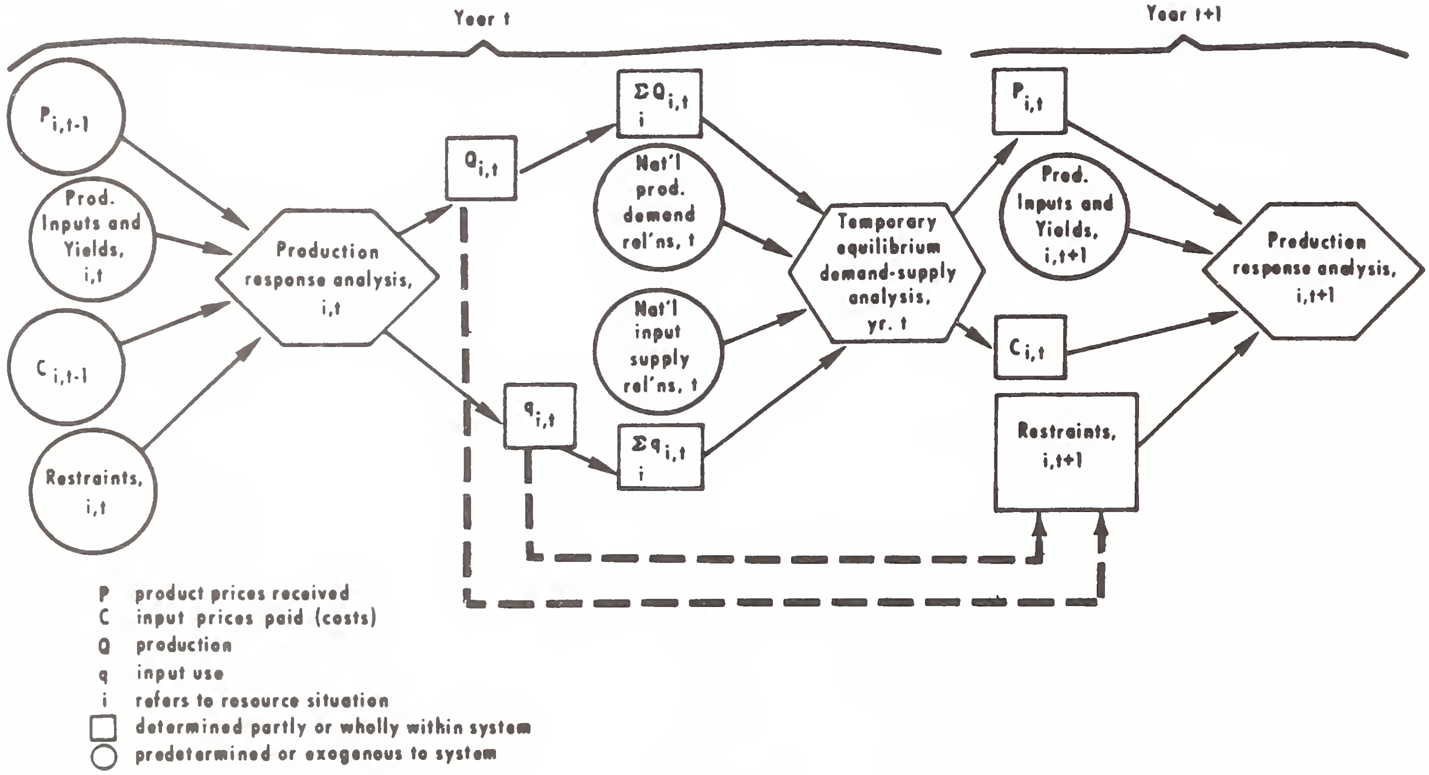

Figure 1

made to estimate "harvested" acreage within the model. That is, the analysis does not explain, or take into account, changes in post-planting practices or the effects of weather. Harvested acres are derived from planned (planted) acres using the average or expected differential between the two figures.

The programming solution also includes estimates of planned production, obtained by multiplying acreages times expected, normal, or assumed yields (whichever is appropriate to the policy problem at hand). The production so estimated for a given resource situation in year t is denoted by $Q_{i,t}$ in figure 1. This $Q_{i,t}$ includes a vector (or set) of production estimates, one for each commodity produced by the unit. The summation of these outputs across resource situations and areas (with the addition of production, if any, in areas excluded from the model) gives us a set of national estimates, or $\sum_i Q_{i,t}$. Similarly, on the input side, the quantities of inputs associated with the production estimated for a given resource situation are denoted by $q_{i,t}$, and the national quantities by $\sum_i q_{i,t}$.

<u>Intermediate-run analysis</u> (more than 1 year ahead): Having obtained estimates for next year, we can go on to subsequent years by introducing product demand and input supply relations. These are needed to determine the effects of aggregate output on the product and factor prices farmers will expect in the subsequent year. This can be done in a fairly simplified way using national relations, as illustrated in figure 1.

When the national estimate of production for a given commodity in year t is plugged into the demand function for that commodity, we obtain the market price that would be associated with that production.[9] This is done separately for each commodity. The resulting "temporary equilibrium" prices, as we call them, when fed back to each submodel--for example using historical price differentials--become or are used to derive the expected prices for year t+1.

[9] Stocks and other factors determining supply, in addition to production, will have to be taken into account beforehand. Also, the demand functions will have to show the effects of Government programs.

The same procedure applies in theory to the input side. Total inputs used in production for year t can be matched with input supply functions to determine "temporary equilibrium" input prices, which are then used to determine expected input prices for year t+1.

Theoretically, area product demand relations might be used instead of national relations. In this case, the programming results could be fed into transportation models (augmented to include relations instead of fixed demands). The results of the transportation model analysis would consist of area prices.

The feedback described above involves more than the derivation of expected prices for year t+1 based on the solutions for year t. Flexibility and other restraints for t+1 also depend on the estimates for year t, as suggested by the dashed line in figure 1.

The input and yield data and other components of the system determined outside the analysis are then updated to year t+1 and a new round of computations begins, this time to estimate production and resource use in t+1. Thus, the intermediate-run application of the model will generate a sequence of year-to-year estimates of planned acreage, production, and resource use. Also, given the product demand and input supply functions, and implied market prices, we obtain a rough measure of changes in farm income.[10]

Longer-run analysis: Certain policy questions will continue to require analysis of longer-run equilibrium adjustments in commercial agriculture. Public policy makers need such a frame of reference to measure the economic gains and losses associated with alternative courses of action and to establish policy goals. Thus the policy issue may require a comparison of equilibrium (how production would be allocated assuming all economic adjustments are made) and the most likely adjustment path. Rather than treat these two problems as entirely different research studies, a more meaningful comparison may be possible if the same basic model is used for both.

Although longer-run analyses are not in our immediate plans for the national model research, the model can also be used for such problems. This will probably involve the same general procedure outlined for the intermediate-run analysis, except that the variables will not be time-dated. Each round of computations will be interpreted as a "correction" for the effects of aggregate output on prices, and the sequence will be repeated until the prices we have at the end of one round are essentially the same as those we used at the start of that round.

A Historical Test

In most projects of this kind, where ex ante predictive estimates are the desired research product, one first converts the methodology into an empirical model and then tests that model against history. This procedure allows the analyst to evaluate the model's performance without waiting until model estimates can be compared with future outcomes.

Accordingly, we began in 1964 by developing an experimental model and testing it against a historical period of sufficient length to permit a meaningful interpretation of results. The period 1960-64 was chosen for this purpose. The 5-year test was limited to an evaluation of the model's performance looking only 1 year ahead (the short-run application).[11]

Forty-seven producing areas were delineated for the test (shown in white in figure 2). A total of 95 resource situations was defined. These represent differences in farm size, soil type, source and cost of irrigation water, and other characteristics.

The activities and restraints included in each submodel represented the alternatives available to producers during the period. Emphasis was placed on major field crops--cotton, wheat, feed grains, and soybeans. Other crop alternatives were included in areas where their production is interrelated with the production of major crops. Examples are flax, oats, extra long staple cotton, and sugarbeets. Livestock

[10] This intermediate-run operation is a simplified version of what Richard H. Day has called "dynamic coupling." See (3).

[11] The test was managed by four professionals in Washington, D.C. (W. Neill Schaller, project leader, Fred H. Abel, W. Herbert Brown, and John E. Lee, Jr.). About 20 members of the Division's field staff located at State universities spent an average of 2 to 3 months each constructing submodels and assembling data.

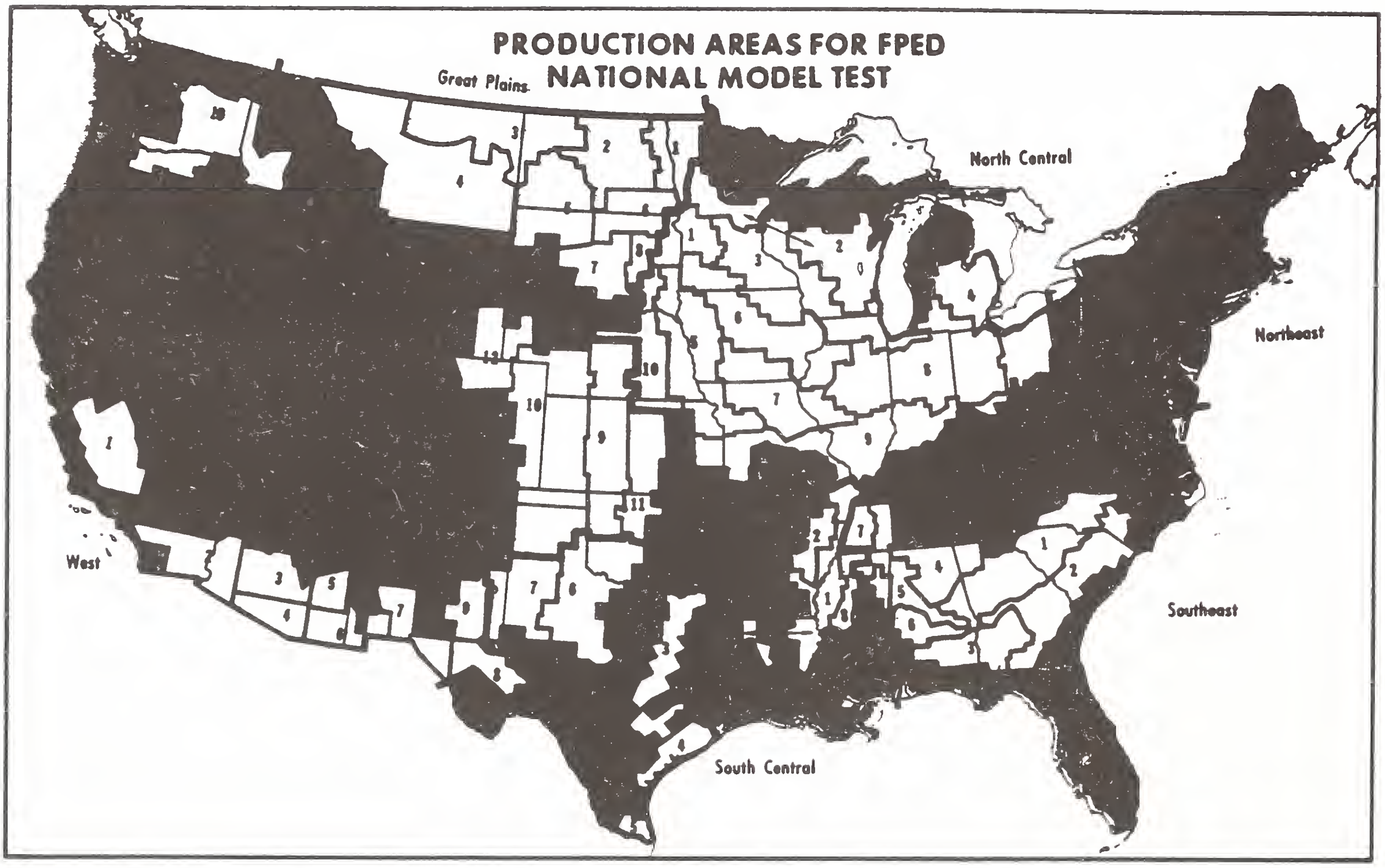

Figure 2

activities were included only in areas where it was believed that their inclusion would improve the model's ability to estimate crop acreages. Government programs for cotton, wheat, and feed grains were also built into each submodel.

The model areas shown in figure 2 accounted for the bulk of the 1960-64 U.S. acreage of most major crops: 85 to 90 percent of the upland cotton and soybeans; 80 to 85 percent of the corn, wheat, and grain sorghum; and 68 percent of the barley. As a rule, these areas accounted for somewhat higher proportions of U.S. production, as many of the omitted areas had lower yields.

The technical coefficients used in the test were based largely on the data developed for the regional adjustment studies discussed earlier. Other required data consisted of county acreage and yield estimates from USDA's Statistical Reporting Service, and county allotments, base acres, payments, and diversion data from Agricultural Stabilization and Conservation Service.

The 95 programming submodels varied in size and complexity from one area to the next. The average submodel for 1964, the last year of the test, had 39 rows, 28 real activities, and 309 matrix elements. The 95 submodels had a total of 3,700 rows, 2,630 columns, and 29,000 matrix elements.

SELECTED ACREAGE RESULTS

The results reported here are limited to the acreage estimates for six crops: upland cotton, wheat, corn, barley, grain sorghum, and soybeans. Also examined are the model estimates of acreage diverted under voluntary participation programs for feed grains, and wheat.

Table 1 shows the percentage deviation of model estimates from actual acreage for each of the six crops.[12] These results are summarized for the FPED field groups outlined in figure 2, as well as for the total model.

To interpret such a large and varied assortment of test results is a real challenge. Obviously the model estimates are relatively close to actual response for some commodities in some areas, but not for others. Unlike the results of regression analysis, the solutions to a programming (economic) model cannot be summarized by statistical measures of reliability. Nevertheless, a number of important observations can be made:

1. The deviations shown in table 1 tend to be smaller for the total model than for the FPED field groups. Though not shown in the table, the estimates for areas and resource situations within each field group tend to be less accurate than those for field groups.

This phenomenon, though not surprising, opens the question as to how one ought to interpret the more aggregative results, knowing that there are larger, offsetting errors in the estimates at lower levels of aggregation. The appropriate interpretation would seem to be that the model is not unlike a sampling procedure which gives the results for the aggregate greater validity than those for the parts. Of course this reasoning suggests that to provide estimates for areas and resource situations that are just as useful as those for the total model, either we need more realistic submodels or we must use other methods to obtain those estimates.

2. A second observation is that the model estimates for allotment crops, such as cotton and wheat, tend to be more accurate than those for nonallotment crops. This, too, is not surprising. Because the allotment crops are generally the most profitable alternatives, one expects them to go to their allotments in a programming solution.

3. The errors of estimation for a crop whose acreage fluctuates quite a bit are usually larger than for a crop with a relatively stable acreage path. There is also a tendency for the model to overestimate the acreages of the more profitable crops that are not restrained by allotments. This is due mainly to the use of a very simple technique to derive flexibility restraints. We used as flexibility coefficients (allowable rates of change) the average of actual percentage changes since 1957, plus a standard deviation. The same rule was applied throughout. Test results clearly suggest that different techniques of estimating flexibility coefficients should be used for different crops in different areas.

Flexibility coefficients are not the only source of error attributable to upper and lower bounds. The base acreage (X_{t-1}) may also be a culprit. Use of the preceding year's acreage as the base often produces unreasonable bounds when that acreage fails to represent the real intentions of farmers. For example, if poor weather at planting time in year t caused farmers to plant less than they had intended, flexibility restraints for year t+1, when set around that acreage, are likely to misrepresent the appropriate limits for t+1. This situation suggests that it may be better in some cases to use an average or trend acreage instead of X_{t-1}.

4. The 95 programming submodels yielded a total of 3,270 acreage estimates in the 5-year test. Two-thirds of these estimates were restrained by the crop's own upper or lower flexibility restraint. While this clearly indicates the importance of improving the upper and lower bounds,[13] it also reflects the absence of other restraints. If the model can be more fully specified on the restraint side, its dependence on flexibility restraints will be lessened. Unfortunately, it is more difficult to quantify restraints on physical inputs, such as cropland and labor, for an aggregate-predictive model than for a farm model.

[12] Percentage deviations provide a good summary but do not tell the whole story. One must take account of the absolute acreage levels to properly evaluate these results. In table 1, the deviations for the "total model" provide this information indirectly. For example, the 1962 wheat estimate for the Southeast is 105 percent in error, but the total model deviation is only 4 percent.

[13] It bears noting, however, that the "effectiveness" per se of flexibility restraints is not necessarily an indication of model weakness. Some have argued that it is--that if the bounds are effective consistently, one does not need to use programming. He can take the bounds as estimates of response. This argument ignores the fact that the analyst will not always know in advance which bounds will be effective or at what price and restraint conditions individual bounds would no longer be effective.

Table 1.--Percentage deviation of model acreage estimates from actual data for selected crops, 1960-1964[a]

Crop	1960	1961	1962	1963	1964	Average
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Cotton, upland:						
Southeast.........	13	7	9	10	0	8
South Central.....	1	1	0	0	1	1
West..............	1	1	0	1	8	2
Total...........	2	2	2	2	1	1
Wheat:						
Southeast.........	63	15	105	7	2	38
South Central.....	2	10	5	5	21	9
West..............	1	0	7	1	4	3
Great Plains......	3	0	1	10	1	3
North Central.....	21	5	17	10	10	13
Total...........	7	1	4	9	0	4
Corn:						
Southeast.........	6	10	8	4	5	7
South Central.....	3	20	17	7	3	10
Great Plains......	8	15	10	4	6	9
North Central.....	12	26	18	9	17	16
Total...........	11	24	17	6	15	15
Barley:						
West..............	4	1	5	5	0	3
Great Plains......	7	14	1	2	0	5
North Central.....	26	22	3	35	21	21
Total...........	4	10	0	2	1	3
Grain sorghum:						
South Central.....	5	9	3	2	17	7
West..............	11	12	9	4	21	11
Great Plains......	22	26	3	9	37	19
North Central.....	13	116	19	10	29	37
Total...........	13	31	5	3	27	16
Soybeans:						
Southeast.........	2	0	17	10	11	8
South Central.....	6	1	1	2	2	2
Great Plains......	56	15	131	33	18	51
North Central.....	6	2	13	12	5	8
Total...........	7	1	12	10	4	7

[a] Deviations are without regard to sign.

5. Errors in the model's estimates of crop diversion under voluntary Government programs (table 2) can be traced to a number of causes. The use of aggregates rather than individual farms is one. A linear programming model picks the most profitable alternatives open to the unit (subject to restraints). Therefore, the solution can be expected to include only one of the options offered in a voluntary program. This kind of solution makes sense for a single farm. It also makes sense for an aggregate model if the aggregate consists of homogeneous farms. In practice, the aggregate does not. We accounted for the expected range of individual farm responses in each resource situation by adding flexibility restraints on the aggregate diversion of each crop that were narrower than the limits specified in the program.

Historical data on actual diversion are far less useful for estimating such restraints than past crop acreages are for estimating crop bounds. This is because the history of diversion programs is limited and year-to-year changes in program provisions cast doubt on the validity of diversion bounds estimated from history. Consequently, our diversion bounds for the test--though reflecting history--had to be set somewhat arbitrarily. The extent to which these bounds were too wide, or too narrow, may explain part of the discrepancy between estimated and actual diversion.

One way to alleviate this difficulty is to use a larger number of resource situations per area, basing them on characteristics that influence farmers' decisions to go into or stay out of a voluntary program. Knowing what characteristics to define and having data to permit a breakout of new situations are the main problems involved in this approach.

The discrepancies shown in table 2 are too large to suggest that the model alone could provide reliable estimates of response to voluntary programs. Many factors affect farmers' response to such programs in addition to those quantified in the model (length of signup period, farmers' views on farm policy, their understanding of the program, and so on). But with the possibility of bringing more of these factors under control in the overall analysis, the outlook for the model is encouraging.

Table 2.--Percentage deviation of model diversion estimates from actual diversion, 1960-1964[a]

Crop	1960	1961	1962	1963	1964	Average
Feed grain diversion:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Southeast.........	(b)	(c)	7	28	9	15
South Central.....			28	1	25	18
West..............			10	9	9	9
Great Plains......			6	9	22	12
North Central.....			20	15	14	16
Total...........			9	9	16	11
Wheat diversion:						
Southeast.........	(b)	(b)	49	12	3	21
South Central.....			39	64	118	74
West..............			5	194	11	70
Great Plains......			27	49	15	30
North Central.....			24	142	130	99
Total...........	--	--	27	62	33	41

[a] Deviations are without regard to sign.
[b] Diversion program not in effect.
[c] Diversion program in effect, but data on actual diversion not available.

In summary, the estimation errors revealed in the test fall into two general categories: Errors of aggregation, and errors of specification (9, 17). Aggregation errors, illustrated above for diversion results, are common to all research designed to yield aggregate estimates, regardless of the unit of analysis. The basic problem in the case of an aggregate model is that when firms are grouped together for analysis, as though they were homogeneous, the resulting estimates invariably differ from the estimates that would be obtained by analyzing each firm separately. Included under errors of specification are those due to the way the model simulates production alternatives, expected earnings, and restraints--as well as the decision-making process itself.

The errors in both categories are frequently due to scarcity and inferior quality of data. The structuring of an analysis is often guided by data availability, and the absence of certain data often forces the analyst to make compromises that may cause errors, although hopefully they will not be large ones.

The national model test was a test of the hypothesis that one can evaluate the effects of certain factors on farmers' aggregate production response using a profit-maximizing, recursive model with flexibility restraints. The results, though pointing to certain weaknesses in the model, support that hypothesis. Moreover, one must evaluate a model in terms of whether it can provide better information at reasonable cost than that obtainable from alternative methods.

An Ex Ante Test

The historical test taught us a great deal, but it did not answer several questions about the model's potential performance in a real world, or ex ante, application. For one thing, the test did not examine the model's true predictability because actual outcomes were known before the analysis was conducted. In fact, certain data on crop acreages and participation in Government programs for years through 1964 were used to derive restraints for each year of the test. This use of "advance information" was unavoidable when data for years prior to the test period were insufficient.

As explained earlier, the cobweb approach requires data for year t to estimate response in year t+1. Data for year t were available when the historical analysis was conducted. We realized that considerable data would not be available for ex ante applications. County acreages and yields for a given year are not reported until a year or so later. Hence, another unanswered question is, what do you substitute for these data? And what effect will this substitution have on the model results?

Finally, the test did not really answer the critical question, can a fairly comprehensive model be structured and updated during year t in time to provide estimates of response that are useful to those who have to make policy decisions for year t+1?

In view of these considerations, we decided early in 1967 to update the model and apply it to policy questions concerning response in the 1968 production year. The idea was to catch up with time--to begin to do before-the-fact analyses on an annual basis--all the while making improvements in the model and the data, and developing complementary models wherever appropriate.[14]

The initial step in the 1968 analysis was to update the historical model, incorporating a number of structural and data improvements, on a time schedule that would test the practicality of the model. A few changes were made in area boundaries and numbers of resource situations (the 1968 model includes 52 areas and 83 situations). Flexibility restraints were

[14] Early in 1967, 7 members of the Division's field staff were named regional analysts and given increased responsibility for the planning and conduct of the research: W. C. McArthur, Athens, Ga. (Southeast), Percy L. Strickland, Stillwater, Okla. (South Central), Walter W. Pawson, Tucson, Ariz. (Southwest), LeRoy C. Rude, Pullman, Wash. (Northwest), Thomas A. Miller, Ft. Collins, Colo. (Great Plains), Gaylord E. Worden, Ames, Iowa (North Central), and Earl J. Partenheimer, University Park, Pa. (Northeast). Glenn A. Zepp, Storrs, Conn., replaced Partenheimer as the Northeast Analyst during the year. Jerry A. Sharples shared with Worden the responsibilities of analyst for the North Central region until mid-1967 when Sharples transferred to Washington, D.C. for a temporary assignment with the Washington staff.

estimated in a number of ways considered appropriate for individual crops and areas.[15]

A benchmark policy situation was defined for 1968. It assumed that 1967 product prices would be those expected in 1968. Other assumptions included trend changes in inputs, yields, and costs, and a continuation of 1967 Government programs for cotton, wheat, and feed grains. Our plan was to complete the preparation of all benchmark data by July 1, 1967 (4 months after actually starting). Following the programming stage, we intended to analyze selected policy questions concerning proposed changes in Government programs.

As it turned out, preparation of the benchmark material was not completed until mid-September, and the benchmark programming was not finished until November. This "dry run" analysis proved that faster and more efficient procedures for collecting and processing data, and an earlier start, are needed if the national model is to make a timely contribution to policy questions. Most of the key decisions concerning 1968 program provisions were made before the analysis was complete. However, certain proposed changes in the 1968 cotton program were studied with the national model, mainly to gain further experience in policy application and to learn more about the model's capability. The results of the benchmark and cotton analyses are still being studied, but as in the case of the historical test, a few observations can be made:

1. We do indeed learn more by doing than by armchair reasoning. The 1968 experience suggested ways of reducing the time needed to update the model and complete the analysis. Current plans to update to 1969, and then to 1970, will include use of faster and more efficient data assembly and processing procedures.

Nevertheless, it is probably unrealistic at this stage of our experience to think of using the model to "field" a specific policy question requiring an answer in a matter of days, or even weeks. Considerable time is needed to study and evaluate the large quantity of results; this is often overlooked in the current age of electronic computation. A more reasonable approach is for the analysts--through good communication with policymakers--to anticipate the main policy issues early in the year and to develop a basic set of response estimates that can be used to shed light on specific questions that arise as the year progresses.

This discussion may suggest that the national model analyst is one who responds only to questions asked by others. On the contrary, the analyst not only can but should extend his role to that of studying policy alternatives which he believes to merit research, even though the public and policymakers have not posed any questions. Such a role also applies to the analysis of a question that has been asked. For example, if we are asked to analyze the effects on cotton production of a change in the diversion payment, we should also consider the effects on alternative crops. The results of this research may point out side effects of a program that had not been anticipated.

2. In the 1968 test, we came to grips with the problem of not having actual 1967 prices and acreages on hand when the analysis was conducted. The prices we used were based on 1967 projected U.S. prices developed by the Department, and individual crop acreages were derived from "March 1 planting intentions." The resulting input data are not as satisfying to us as their counterparts in the historical model, but by using them we learned more about their limitations--and possible alternatives--than if we had chosen the security of further historical testing.

Concluding Remarks

At a workshop on the national model in October 1967, Washington and field participants looked especially at where we had been and how we ought to proceed. It was agreed that the current national programming model should be viewed as a central activity, but by no means the only activity, in the Division's program of research on aggregate production adjustments. We need an integrated research program that includes an improved version of the current model plus other analytical means

[15] The paper by Thomas A. Miller in this issue of Agricultural Economics Research describes an approach used in the Great Plains to estimate flexibility restraints. Miller's regression model can also be used by itself without the additional programming step. The choice would seem to depend on the research problem.

of researching questions requiring more micro detail than is possible in the current model, as well as certain aggregate questions needing almost immediate answers.

Several improvements in the model were planned. These include redelineation of area boundaries, better estimates of restraints, and collection of new data. Plans were also made to experiment with statistical models and to study the possibilities of using the results of individual farm analyses to provide better input data to the aggregate model or to adjust the estimates obtained from the latter.

A final point: The application of a formal model to policy research is often accompanied by skepticism on the part of some and by the belief on the part of others that what comes out of a computer is automatically right. Both reactions are incomplete. No formal model has yet predicted aggregate response with consistent accuracy. Neither has any informal model. But all too often, formal models are reported in the literature as though their purpose is to replace informal methods. A really effective tool kit must include both types.

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Excess Capacity and Adjustment Potential in U.S. Agriculture

By Leroy Quance and Luther Tweeten

Recursive aggregate demand and supply functions are used to simulate the ability of the farm sector to adjust during the 1970's to three policy alternatives. Different output demand elasticities and shifts in the supply and demand for farm output were assumed. Within reasonable bounds, agriculture could remain economically viable during the 1970's under policies diverting about 6 percent of potential output. An average of 6 percent was diverted from the market by Government production control, storage, and subsidized exports in 1962-69. Returning to a free market immediately or by 1980 would place severe financial strain on the farm sector.

Key words: Aggregate U.S. agriculture; excess capacity; Government programs; net farm income; simulation.

Ability of the farming industry to adjust to changing economic conditions depends on the magnitude of excess capacity, the characteristics of supply and demand, and the nature of public policies to deal with excess capacity. Excess capacity is defined in this paper as farm production in excess of market utilization at socially acceptable prices—current prices achieved by Government intervention. An operational definition of excess capacity is the value of production diverted from the market by Government production control, storage, and subsidized exports relative to potential farm output at current prices. One objective of this paper is to estimate excess capacity for recent years.

Excess capacity represents economic imbalance in resource use as well as output. The resource imbalance has been estimated elsewhere (*1*); measures of excess capacity in this paper focus on production.[1] The ability of the farm economy to cope with excess capacity, and the output, price, and income levels that would attend a more market-oriented farm industry, depend heavily on the characteristics of supply and demand. A second objective of this paper is to estimate output, prices, and net farm income from 1969 through 1980 under alternative assumptions about the elasticities of and shifts in demand and supply and under selected Government policies. These policies include continuing the programs of the 1960's, immediately eliminating Government programs, and gradually eliminating Government programs over the 1970's. The farm economy is simulated through 1980 to provide information on how it might adjust to different economic conditions and policies.

Footnotes are at end of article.

Excess Productive Capacity

Given the supply and demand parameters and other characteristics of agriculture and its environment, our farm plant has the capacity to produce an aggregate output generally greater than that demanded at prices with a socially (politically) acceptable level and stability. In a free market, the burden of excess capacity would fall on the farmer in terms of uncertain and generally low product prices which complicate investment decisions and yield low returns, and on the consumer via erratic supplies and prices although average consumer prices would be somewhat lower. In a free market, excess capacity as defined herein would not exist. But society has chosen to modify the market mechanism by diverting from regular markets quantities in excess of that level which clears the market at socially acceptable prices.[2]

Tyner and Tweeten (*6*) estimated that excess productive capacity in 1955-61 ranged from a low of 5.3 percent in fiscal year 1957 to a high of 11.2 percent in 1959.[3] Tyner and Tweeten's procedure for measuring excess capacity is followed in this study. Annual excess production during 1962-69 is defined as the value of potential farm output diverted by Government land withdrawal programs plus the value of production diverted from commercial markets by Government storage operations (Commodity Credit Corporation) and subsidized exports (P.L. 480, etc.). The sum of the value of these diversions (at current prices) for major farm commodities is defined as aggregate excess production. And the ratio of this sum to the value of potential agricultural production is the relative excess capacity in each particular year (*6*, p. 23).

Table 1.—Estimated value of net additions to CCC stocks, seven major commodities, fiscal years 1963-69[a]

(In millions of dollars)

Year ending June 30	Wheat	Rice	Feed grains[b]	Cotton	Peanuts	Tobacco	Dairy products[c]	Total
1963	-26.2	8.3	-225.6	430.6	77.7	—	-10.7	254.1
1964	-347.5	-1.0	279.3	46.1	-77.7	—	-15.2	-116.0
1965	-246.4	-1.4	-361.9	328.6	—	—	-1.4	-282.5
1966	-498.8	-3.6	-409.4	278.7	—	—	-2.1	-635.2
1967	-301.3	-2.2	-380.9	-326.3	.7	—	15.8	-994.2
1968	-26.4	-.3	-8.0	-655.7	-.7	—	-5.6	-696.7
1969	74.9	29.0	188.6	-54.4	—	—	4.1	242.2

[a]Net changes in CCC inventories times seasonal average price.
[b]Sum of rye, corn, grain sorghum, barley, and oats.
[c]Milk equivalent of net USDA acquisitions times manufacturing milk prices.

Source: Quantities from Annual Reports of Financial Condition and Operations (Commodity Credit Corporation) and Dairy Situation (DS 327, Sept. 1969, Economic Research Service) were weighted by season average prices from Agricultural Statistics, various issues, except that dairy products (milk equivalent) were weighted by manufacturing milk prices.

Excess capacity is measured for the fiscal year (ending June 30) to conform with available data. Commodity Credit Corporation (CCC) and export data are by fiscal year. Quantities are weighted by average prices received by farmers during the crop marketing year. Program diversions and value of total farm output for year t, e.g., 1967, are used in calculations for "year" t-(t+1), e.g., 1967-68. To illustrate, the "analysis year" 1967-68 relates to net CCC stocks and subsidized exports for fiscal 1968, land diversions for 1967, marketing year prices for 1967-68, and value of total farm output for 1967.

CCC Storage Operations

The Commodity Credit Corporation acquires stocks through (a) acquisition of commodities pledged as collateral for price support loans, and (b) purchases of commodities from processors or handlers, or from producers by purchase agreements (*8*). CCC diversions shown in table 1 for seven major commodities are *net* additions to CCC stocks. These values were calculated as the quantities diverted times the seasonal average price received by farmers for the respective commodities.

A marked downward trend for CCC diversions in 1962-68 is apparent for all commodities except cotton. This trend reflects greater emphasis placed on supply control and heavy exports from CCC stocks under Government programs (P.L. 480, etc.) to relieve the pressure of large CCC stocks accumulated in earlier years and to aid food deficit areas of the world. In 1969, reduced exports resulted in a $242 million increase in CCC inventories.

Exports Under Aid Programs

Conceptually, at least two approaches can be used to estimate excess capacity diverted from commercial markets through export programs. One approach is to estimate the amount of commercial exports to aid recipients in the absence of aid programs. Andersen (*1*) estimated that, on the average, each ton of wheat (the major component of aid exports) under U.S. aid programs replaced 0.41 ton of commercial wheat imports from 1964 to 1966. This implies that the residual, 0.59 ton, should be imputed to excess capacity. Since the U.S. had substantial reserves of food, the major share of commercial exports replacing aid would have come from U.S. supplies. It appears that at least half of U.S. food aid exports could be charged to excess capacity based on rates of commercial export substitution.

The second approach is to measure the cash equivalent value of food aid. With cash, aid recipients could have purchased fertilizer plants, irrigation equipment, technical assistance to develop improved crop varieties, or other items. In the 3-year period 1964-66, the cash equivalent value of food aid was 48.1 percent of the reported market value of food aid exports, excluding transportation costs (*1*). Thus approximately half of the value of food aid is imputed to real foreign aid (foreign economic development); the other half to support of domestic farm prices (excess capacity).

We assume that half of exports under Government programs are charged to excess capacity in table 2 for seven major commodity groups for the years 1962-68. These diversions fluctuated around $700 million from 1962 to 1968 with wheat accounting for over half of the diversions. In 1969, exports under aid programs

Table 2.—Estimated value of excess capacity exported under Government programs, seven major commodities, fiscal years 1963-69

(In millions of dollars)

Year ending June 30	Wheat	Rice	Feed grains[a]	Cotton	Peanuts	Tobacco	Dairy products	Total
1963	421.0	42.7	54.8	81.0	—	18.4	48.0	665.9
1964	434.4	43.5	41.5	71.0	—	18.0	69.5	677.9
1965	495.4	34.4	38.1	82.5	—	17.7	51.2	719.3
1966	468.6	30.0	56.8	61.8	—	45.0	45.4	707.6
1967	322.8	65.6	103.5	82.5	—	53.4	51.0	678.8
1968	383.6	68.5	59.5	87.4	—	52.6	55.0	706.6
1969	199.0	80.8	18.5	45.0	—	14.4	71.2	428.9

[a]Includes corn, grain sorghum, barley, oats, and rye.

Sources: Econ. Res. Serv., 12 Years of Achievement Under Public Law 480, ERS-Foreign 202, Nov. 1967, and Foreign Agricultural Trade of the United States, 1968, p. 22; and (*8*).

decreased $278 million, more than offsetting the $242 million net additions to CCC stocks.

Land Withdrawal Programs

Net additions to CCC stocks and subsidized exports remove excess output already produced. Growing emphasis during the 1960's was placed on removing land from production to control output before it was produced. Estimates of land diverted from various crops are made from USDA data (*2*, *7*). A crucial question is "How productive is the diverted land?" Many persons agree that farmers divert marginal cropland and that, on the average, diverted land is less productive than land in production. Ruttan and Sanders estimated that productivity of diverted land may be as little as one-third that of land in production (*3*). But others (*12*) estimate that diverted acres may be 90 percent as productive as cropland in production. To estimate the potential farm output diverted by land withdrawal programs, we arbitrarily assume that yields on diverted acres would be 80 percent of average crop yields for each respective crop and year. Estimates of the potential production of three major crops were weighted by average prices received by farmers to obtain the value of potential farm output diverted by Government land withdrawal programs (table 3). The three crop categories in table 3 accounted for the normal use of 63 percent of the cropland in the Conservation Reserve in 1960 (*2*, p. 47), and the proportion these three crops comprise of total diversions by specific commodity programs would be even greater.

Feed grains account for about three-fourths of the potential production on diverted acres which, according to our estimates, was highest ($3.2 billion) in 1966 and lowest ($1.9 billion) in 1967, and was $2.7 billion in 1968. Diversions by land withdrawal programs generally increased except in 1963 when acres diverted from corn production decreased 3.3 million acres, in 1964 when the value of wheat acreage diversions declined by almost two-thirds, and in 1967 when concern over our dwindling surpluses and the world food deficit caused a reduction of production controls.

Aggregate Excess Capacity

Estimates in tables 1 to 3 of net additions to CCC stocks, Government-aided exports, and potential production on diverted acres are summarized and added

Table 3.—Estimated value of diversions by land withdrawal programs, three major crops, crop years 1962-68

(In millions of dollars)

Crop	1962	1963	1964	1965	1966	1967	1968
Wheat . . .	552.4	550.7	198.2	250.1	334.7	34.7	279.2
Feed grains	1,845.2	1,651.3	1,924.0	2,325.9	2,493.8	1,429.8	2,137.3
Cotton . .	60.2	64.8	104.4	151.8	389.4	468.7	290.3
Total . .	2,457.8	2,266.8	2,226.6	2,727.8	3,217.9	1,933.2	2,706.8

Sources: Acres removed by the conservation reserve and various commodity programs are from Agricultural Statistics, various issues. Estimates of normal use of land in the conservation reserve were taken from Economic Effects of Acreage Control Programs in the 1950's (*2*). Assumed production on diverted acres was weighted by the average prices received by farmers.

Table 4.–Government diversions, farm output, and excess capacity in agriculture, fiscal years 1963-69

Year ending June 30	Government diversions				Farm output[a]	Excess capacity[b]
	CCC	Land withdrawals	Subsidized exports	Total		
	Mil. dol.	*Mil. dol.*	*Mil. dol.*	*Mil. dol.*	*Mil. dol.*	*Percent*
1963.......	254.1	2,457.8	665.9	3,377.8	38,806.6	8.19
1964.......	-116.0	2,266.8	677.9	2,828.7	40,391.9	6.63
1965.......	-282.5	2,226.6	719.3	2,663.4	41,111.9	6.15
1966.......	-635.2	2,727.8	707.6	2,800.2	40,522.7	6.48
1967.......	-994.2	3,217.9	678.8	2,902.5	37,096.4	7.20
1968.......	-696.7	1,933.2	706.6	1,943.1	40,904.3	4.54
1969.......	242.2	2,706.8	428.9	3,377.9	40,308.0	7.85

[a]Net farm output in 1957-59 dollars adjusted to current values by the index of prices received by farmers (1957-59 = 100). Farm output estimates are from worksheets of the Farm Adjustment Branch, Farm Production Economics Division, ERS.

[b]Government diversions as a percentage of potential farm output where diversions of land withdrawal programs are added to actual farm output to more adequately reflect "total capacity" of agriculture.

to show aggregate excess production in table 4. Total diversions are then expressed as a percentage of potential farm output for fiscal 1963 to 1969 as a measure of excess capacity. These estimates are probably the lower bound on real excess capacity. There is some excess capacity in commodities not included in our estimates. If government programs were eliminated, farmers could bring more "new lands" into production as well as most of the diverted acres accounted for in this study.

Our estimates indicate that the adjustment gap in U.S. agriculture in the 1960's ranged from 6.2 to 8.2 percent, except for 1968, when our dwindling carry-over and the world food gap led to a large decrease in diverted acres. In the 1960's, CCC stocks declined in every year except 1963 and 1969. Net declines in CCC stocks in recent years just about offset subsidized exports, and excess capacity is approximately equal to what could have been produced on land in Government land withdrawal programs. In simulating possible future adjustments in the farm economy, we use 6 percent of potential agricultural output as a measure of current excess capacity.

Supply Parameters

Supply elasticities indicate the speed and magnitude of output adjustments in response to changes in product price. The price elasticity for aggregate farm output is especially important because it measures ability of the farming industry to adjust production to changing economic conditions continually confronting it in a dynamic economy.

Farmers have considerable latitude to substitute one commodity for another in production over a long period. Eventually, this should lead to adjustments among commodities until comparable resources are earning similar rates of return in production of each commodity. And because farm resources are adjusted much more easily among farm commodities than between farm and nonfarm commodities, it follows that the aggregate supply response, which tends to determine total resource earnings in agriculture, is less than the supply response for individual commodities (*5*, p. 342).

Point estimates of the aggregate supply elasticity were computed by the authors using three approaches: (a) Direct least squares, (b) separate yield and production unit components for crops and livestock, and (c) separate input contributions (*5*).[4] From these approaches we conclude that the supply elasticity is 0.10 in the short run and 0.80 in the long run for decreasing prices. But for increasing prices, the supply elasticity is considered 0.15 in the short run and 1.5 in the long run.

Shift in supply due to nonprice variables.—The best available indicator of the shift in the aggregate supply function for farm output is USDA's productivity index (*10*). With a rather stable input level from 1940 to 1960 and rising output, productivity per unit of input increased about 2 percent per year from 1940 to 1960. But the productivity index was only 2.9 percent higher in 1968 than in 1960—the annual 1960-68 increase was only 0.35 percent. The slowing of the increase is caused in part by the fact that the 1947-49 weights used in constructing the index were inappropriate for the 1960's. In our analysis, partly to compensate for a lack of confidence in past estimates of shift in aggregate supply over time and partly to simulate different levels of technological change in the future, we alternatively assume a 0.0, 1.0, and 1.5 percent increase per year in quantity supplied, due to technology and other supply shifters.

Demand Parameters

Many forces influence the demand for farm output. Some forces are social and some are political, but many are economic factors that grow out of the market system as it reflects increased population and the changes in consumption in response to prices and income. We divide these economic forces into the price elasticity of demand and the annual shift in demand.

Price elasticity of demand.—The demand for U.S. farm output consists of a domestic component (including inventory demand) and a foreign component. Because of the uncertain magnitude of the elasticity of foreign demand for U.S. food, feed, and fiber, there is considerable difference of opinion as to the exact magnitude of the elasticity of total demand. Tweeten's findings indicate the price elasticity of total demand is about -0.3 in the short run and -1.0 in the long run (4). But some economists believe these estimates are too high. In our analysis, we use demand elasticities of -0.3 in the short run and -0.5 in the long run to more nearly conform to conventional wisdom. Use of these elasticities also gives us a chance to view the reasonableness of the alternative estimates in the context of the simulated farm economy.

Shift in demand due to nonprice variables.—It is easier to predict shifts in the demand for farm products in the domestic market than in the foreign market. The annual increment in domestic demand is divided into a population effect and an income effect. In the decade preceding 1968, population grew at an annual compound rate of 1.24 percent. Personal consumption expenditures in constant dollars grew 2.6 percent per capita in the same period. If these trends continue, then based on a 0.15 income elasticity of demand at the farm level, the domestic demand for farm output will grow by 1.24 plus 2.6 (0.15) or a total of 1.63 percent per year.

On the export side, Tweeten projected a 4 percent annual increase in demand for U.S. farm exports to 1980. If 17 percent of farm output is exported, then total demand for farm output is projected to increase 0.83(1.6) = 1.3 percent from domestic sources and 0.17(4) = 0.7 percent from foreign sources, or a total of 2.0 percent per year.

This demand projection may be too optimistic in light of recent developments. If annual export demand grows 3 percent, per capita domestic income 2 percent, and population 1 percent, and if the domestic income elasticity of demand is 0.10, then demand for farm output will grow only 1.5 percent annually. In our analysis, we use shifts in demand of 1.0, 1.5, and 2.0 percent per year.

Adjustment Potential in the 1970's

The adjustment potential of the farm economy is simulated from 1969 to 1980 under three different assumptions with regard to Government diversion programs. The first is that the Government continues to divert 6 percent of potential agricultural output from conventional market channels. Government payments to farmers are assumed to continue at the 1969 level, although, in reality, the level of Government payments would likely be positively correlated to diversions. The second alternative assumes a gradual elimination of diversions and Government payments by 1980. The third alternative is to terminate all diversions and Government payments at the beginning of 1970—an immediate free market. To account for uncertain trends in the supply and demand for farm output and to determine the impact of different assumptions about the elasticity of demand, each policy alternative is simulated over six different combinations of supply and demand parameters. These six different combinations range from the most to the least favorable conditions likely to prevail for agriculture in the 1970's.

The Model

The simulation model is built around a simple recursive formulation of the aggregate supply equation (1) and demand equation (2):

$$(1) \quad Q_t = \alpha_s \left(\frac{P}{P_d}\right)_{t-1}^{\beta_s} Q_{t-1}^{(1-\delta_s)}\, 2.718^{g_s(1-\delta_s+\delta_s T)}$$

$$(2) \quad P_t = \left[Q_t/(\alpha_d\, Q_{t-1}^{(1-\delta_d)}\, 2.718^{g_d(1-\delta_d+\delta_d T)})\right]^{1/\beta_d}$$

The quantity supplied in year t, Q_t is dependent upon the real price in year t-1.[5] This supply equation is basically a free market supply function in that the quantity supplied includes diversions as well as the quantity moving into regular market channels.

The supply quantity, predetermined by past prices and adjusted as necessary for exogenously determined Government program diversions, is then fed into the demand equation to determine price in year t. Demand quantities are equal to supply quantities minus Government diversion. Gross farm receipts in year t are equal to the market clearing demand quantity multiplied by the price in year t. Adding Government payments to gross farm receipts yields gross farm income. Real production expenses, assumed to equal 77.43 percent of the real quantity marketed in year t (a percentage based

Table 5.—Estimates of prices received by farmers, parity ratio, quantity supplied, quantity demanded, and gross and net farm income under alternative Government policies, and with various combinations of demand and supply parameters, 1969 and 1980

Policy alternative and specified variable[a]	Actual values in 1969	Simulated 1980 values when elasticity of demand is—					
		−0.3 (short run) and −1.0 (long run), with annual percent shift in demand/supply			−0.15 (short run) and −0.5 (long run), with annual percent shift in demand/supply		
		2.0/1.0	1.5/1.0	1.5/1.5	2.0/1.0	1.5/1.0	1.5/1.5
Continuation of present programs (6 percent diversion):							
Index of prices received by farmers	275.0	325.6	313.8	305.9	352.8	335.1	322.6
Parity ratio	73.7	70.2	67.7	66.0	76.1	72.3	69.6
Quantity supplied	54,182	56,227	55,458	56,570	58,139	56,869	57,743
Quantity demanded	50,804	52,854	52,130	53,178	54,651	53,457	54,278
Gross farm income	54,598	66,376	63,282	62,949	73,899	68,937	67,458
Net farm income	16,534	17,130	14,719	13,412	22,988	19,138	16,894
Gradual elimination of Government diversions and a free market by 1980:							
Index of prices received by farmers	275.0	310.1	298.9	291.4	329.3	311.9	300.3
Parity ratio	73.7	66.9	64.4	62.8	71.1	67.3	64.7
Quantity supplied	54,182	55,076	54,322	55.392	56,160	55,139	55,966
Quantity demanded	50,804	55,076	54,322	55,392	56,160	55,139	55,966
Gross farm income	54,598	62,105	59,043	58,703	67,256	62,544	61,109
Net farm income	16,534	10,799	8,439	7,101	14,940	11,178	8,973
Free market effective in 1970:							
Index of prices received by farmers	275.0	314.6	303.3	295.4	335.9	322.5	313.5
Parity ratio	73.7	67.8	65.4	63.7	72.4	69.5	67.6
Quantity supplied	54,182	54,684	53,912	55,121	55,936	54,525	55,152
Quantity demanded	50,804	54,684	53,912	55,121	55,936	54,525	55,152
Gross farm income	54,598	62,562	59,464	59,200	68,332	63,942	62,870
Net farm income	16,534	11,619	9,241	7,851	16,223	13,148	11,492

[a]The index of prices received by farmers for all farm commodities and the parity ratio are based on 1910-14 = 100. All quantity figures are in millions of 1969 dollars, and income figures are in millions of current dollars. A 2.0 percent rate of input price inflation is assumed.

[b]The elasticity of supply is 0.1 in the short run and 0.8 in the long run when the parity ratio is decreasing, but 0.15 in the short run and 1.5 in the long run when the parity ratio is increasing.

on 1969 data in the Farm Income Situation (*11*), are inflated 2 percent per year to reflect rising input prices and subtracted from gross farm income to yield net farm income in year *t*.[6] Both marketings and production expenses are net of interfarm sales.[7]

Results

The shift in the supply function due to technological advance was near zero from 1963 to 1970. Assuming a 2.0 percent shift in demand and a stable supply function, farm prices by 1980 could be from 18.6 to 30.1 percent higher than in 1969, and net farm income could increase from $16.5 billion in 1969 to as high as $23.6 billion, depending on the assumed diversion policy and on the choice of demand elasticities. Such highly favorable conditions for agriculture are unlikely in the 1970's and results of these conditions are not tabulated. Alternative estimates, summarized in table 5, indicate that depending on the true magnitude of the elasticity of demand and the shifts in supply and demand, conditions less favorable than those above are likely to exist in 1980. Only beginning and ending year data are given in table 5.

Equal shift in demand and supply.—The farm sector can maintain its viability through 1980 according to estimates in table 5. But the importance of Government diversion programs is evident. Under unfavorable conditions for agriculture—an equal 1.5 percent annual shift in demand and supply, −0.30 and −1.0 elasticities of demand in the short run and long run respectively, and gradual elimination of Government diversion—the parity ratio would fall from 73.7 in 1969 to 62.8 in 1980 and net farm income would decrease approximately 57 percent, from $16.5 billion in 1969 to $7.1 billion in

1980. And our estimates indicate that an immediate reversion to free markets in 1970 would cause havoc in the first year—a decrease of 15 points in the parity ratio and a drastic decline in net farm income. Despite the relatively more favorable long-run outcome of a "one-shot" as opposed to a gradual return to a free market by 1980, the severe short-run impact of the one-shot return seems to rule it out as an acceptable policy alternative.

Demand increasing twice as fast as supply.—If the annual shift in demand for U.S. farm output is double that in supply, as illustrated by the 2.0 percent shift in demand and 1.0 percent shift in supply in table 5, the farm sector would gain by 1980 with continuation of Government programs similar to those of the 1960's. If the short-run demand elasticity is -0.15, prices received by farmers in 1980 would be 119.7 percent of 1969 prices under a policy of gradually eliminating Government diversions and payments. But 2 percent annual input-price inflation causes the parity ratio to decline from 73.7 to 71.1. Net farm income would decrease moderately to $14.9 billion. Under the "immediate free market" alternative, a 72.4 parity ratio and $16.2 billion net farm income result. But if present diversion and payment policies were continued, farm prices would reach 128.3 percent of the 1969 level and net farm income would be $23.0 billion—the highest of any alternative reported in table 5.

Using the higher (absolute value) demand elasticities results in less favorable but viable conditions for agriculture in 1980 if diversion policies are continued. With a continuation of programs to divert 6 percent of potential farm output from commercial markets, net farm income would increase $0.6 billion over the 1969 level.

Demand increasing 50 percent faster than supply with high demand schedule.—The set of outcomes in table 5 which most nearly fits our expectations for 1980 results from a 1.5 percent annual shift in demand, a 1.0 percent annual shift in supply, a -0.3 short-run demand elasticity, and a -1.0 long-run demand elasticity.[8] Depending on Government diversion and payment policies, the parity ratio would decrease 6 to 9 points. With one exception, the quantity of farm products demanded and supplied would increase. Net farm income would decrease moderately to $14.7 billion under continuation of diversion and Government payment policies of the 1960's, and it would decrease severely to $9.2 billion under a 1970 free market supply and to $8.4 billion under a policy that gradually reverts to a free market by 1980. Thus continued diversion and payment programs are needed to avoid a major drop in net farm income. Table 6 contains annual estimates for this set of outcomes.

Estimates in table 6 further illustrate the serious adjustment problems which would likely exist under a one-shot compared with a gradual policy to eliminate Government diversions and payments. Net farm income is higher by 1980 with the one-shot free market policy, but gradual elimination of diversions to achieve a free market by 1980 appears to offer major advantages during the difficult transition period.

If the program of the 1960's is continued, our estimates indicate that prices received by farmers will increase about 1.2 percent per year and will reach 114.1 percent of 1969 prices by 1980. But continued input-price inflation at the assumed rate of 2 percent per year would deflate this nominal price gain to a loss of 6 points in the parity ratio. Quantity supplied would increase $1.3 billion, to reach $55.5 billion by 1980, compared with a quantity demanded of $52.1 billion. Government diversions would decrease $50.3 million, reaching $3.33 billion in 1980. Gross farm receipts would increase 17 percent to $59.5 billion by 1980. According to our assumption, real production expenses rise in proportion to the quantity marketed (no production costs on diverted production), and are then inflated at the annual rate of 2 percent. These expenses would reach $48.6 billion by 1980. With production expenses rising faster than gross farm income, net farm income decreases 1.0 percent per year to $14.7 billion by 1980.

Estimates in table 6 also illustrate some weakness in the model. The deterministic simulation model used to generate the estimates is free of the random and often severe fluctuations which occur in agricultural production and export demand due to weather and other uncontrollable factors. Recent increases in prices paid by farmers exceed the annual 2.0 percent rate assumed in this paper. This aspect of adjustments in the farm economy needs additional research, and some recent estimates by the authors indicate that adjustments in the farm economy may be significantly affected by a higher rate of input-price inflation. Also, the kinds of aggregate adjustment patterns derived above need to be related to classes and types of farms by region. For example, it would be useful to know the impact of a 50 percent drop in net farm income on the viability of the commercial farm unit in 1980 in the different commodity sectors. Attention to these issues will increase the effectiveness of our model in analyzing public policies for dealing with excess capacity in agriculture and the ability of agriculture to adjust.

Summary

Excess capacity in U.S. agriculture in recent years has averaged about 6 percent of potential output. In the

Table 6.—Estimated adjustment patterns of selected variables in the agricultural sector, 1969-80[a]

Year	Index of prices received	Index of prices paid	Parity ratio	Quantity supplied	Quantity demanded	Government diversions	Gross farm receipts	Gross farm income	Production expenses	Net farm income
	1910-14 = 100			*Million 1969 dollars*			*Million current dollars*			
Continuation of present program (6 percen diversion):										
1969	275.00	373.00	73.73	54,181.72	50,803.92	3,377.80	50,803.92	54,597.92	38,063.82	16,534.10
1970	276.04	380.46	72.55	54,229.38	50,975.61	3,253.76	51,167.20	54,961.20	38,956.25	16,004.95
1971	282.03	388.07	72.68	54,251.86	50,996.75	3,255.11	52,300.15	56,094.15	39,751.85	16,342.30
1972	286.42	395.83	72.36	54,260.51	51,004.88	3,255.63	53,122.07	56,916.07	40,553.32	16,362.74
1973	288.37	403.75	71.42	54,400.35	51,136.32	3,264.02	53,622.00	57,416.00	41,470.99	15,945.00
1974	292.34	411.82	70.99	54,520.25	51,249.03	3,271.21	54,479.56	58,273.56	42,393.60	15,879.96
1975	295.75	420.06	70.41	54,660.13	51,380.52	3,279.61	55,256.34	59,050.34	43,352.41	15,697.93
1976	299.34	428.46	69.86	54,806.36	51,517.97	3,288.38	56,077.02	59,871.02	44,387.74	15,533.28
1977	302.91	437.03	69.31	54,960.79	51,663.14	3,297.65	56,905.64	60,699.64	45,351.91	15,347.73
1978	306.52	445.77	68.76	55,121.36	51,814.07	3,307.28	57,751.53	61,545.53	46,394.04	15,151.49
1979	310.15	454.68	68.21	55,287.30	51,970.07	3,317.24	58,612.09	62,406.09	47,464.40	14,941.69
1980	313.82	463.78	67.67	55,457.80	52,130.33	3,327.47	59,487.60	63,281.60	48,562.95	14,718.66
Gradual elimination of diversions, free market by 1980:										
1969	275.00	373.00	73.73	54,181.72	50,803.92	3,377.80	50,803.92	54,597.92	38,063.82	16,534.10
1970	270.76	380.46	71.17	54,229.38	51,271.41	2,957.97	50,481.04	53,930.13	39,182.30	14,747.83
1971	276.85	388.07	71.34	54,147.34	51,489.19	2,658.14	51,835.62	54,939.80	40,135.71	14,804.09
1972	280.73	395.83	70.92	54,016.05	51,658.98	2,357.06	52,735.19	55,494.46	41,073.39	14,421.07
1973	280.72	403.75	69.53	54,077.29	52,012.52	2,064.77	53,093.27	55,507.63	42,181.57	13,326.06
1974	283.88	411.82	68.93	54,091.18	52,320.92	1,770.26	54,009.93	56,079.39	43,280.27	12,799.11
1975	286.16	420.06	68.12	54,124.43	52,648.30	1,476.12	54,784.41	56,508.95	44,422.10	12,086.85
1976	288.72	428.46	67.39	54,157.30	52,975.68	1,181.61	55,617.45	56,997.09	45,592.29	11,404.80
1977	291.22	437.03	66.64	54,194.66	53,307.84	886.82	56,451.12	57,485.84	46,795.68	10,690.16
1978	293.76	445.77	65.90	54,234.56	53,642.91	591.65	57,301.97	57,991.79	48,031.57	9,960.21
1979	296.32	454.68	65.17	54,277.03	53,980.97	296.06	58,165.70	58,510.61	49,300.96	9,209.64
1980	298.91	463.78	64.45	54,321.72	54,321.72	0.00	59,043.35	59,043.35	50,604.38	8,438.97
Free market effective in 1970:										
1969	275.00	373.00	73.73	54,181.72	50,803.92	3,377.80	50,803.92	54,597.92	38,063.82	16,534.10
1970	224.59	380.46	59.03	54,229.38	54,229.38	0.00	44,288.39	44,288.39	41,442.82	2,845.57
1971	283.98	388.07	73.18	53,144.38	53,144.38	0.00	54,878.63	54,878.63	41,425.92	13,452.70
1972	272.02	395.83	68.72	53,317.55	53,317.55	0.00	52,739.98	52,739.98	42,392.11	10,347.88
1973	278.60	403.75	69.00	53,296.70	53,296.70	0.00	53,994.26	53,994.26	43,223.03	10,771.23
1974	286.19	411.82	69.49	53,092.41	53,092.41	0.00	55,253.02	55,253.02	43,918.46	11,334.56
1975	289.27	420.06	68.86	53,018.47	53,018.47	0.00	55,768.70	55,768.70	44,734.43	11,034.27
1976	288.55	428.46	67.35	53,245.26	53,245.26	0.00	55,868.54	55,868.54	45,824.29	10,044.24
1977	293.14	437.03	67.08	53,392.19	53,392.19	0.00	56,913.37	56,913.37	46,869.73	10,043.64
1978	296.25	445.77	66.46	53,566.43	53,566.43	0.00	57,705.58	57,705.58	47,963.09	9,742.49
1979	299.83	454.68	65.94	53,736.87	53,736.87	0.00	58,588.77	58,588.77	49,078.02	9,510.75
1980	303.32	463.78	65.40	53,911.88	53,911.88	0.00	59,463.75	59,463.75	50,222.58	9,241.17

[a]These estimates resulted from a −0.3 short-run and −0.1 long-run demand elasticity; a 0.1 short-run and 0.3 long-run supply elasticity for a decreasing parity ratio and a 0.15 short-run and 1.5 long-run elasticity for an increasing parity ratio; a 1.5 percent annual increase in demand and 1.0 annual increase in supply; and 2 percent annual input price inflation.

1960's, CCC stocks declined in every year except fiscal 1963 and 1969, and that part of exports attributed to excess capacity remained at approximately $700 million until decreasing to $429 million in 1969. Net declines in CCC stocks in recent years just about offset subsidized exports. Thus excess production, $3,378 million in 1969, is approximately equal to what would have been produced on land in Government land withdrawal programs.

We conclude, based on previous studies and on results of the simulation model used in this study, that the best available estimates of supply and demand parameters are: Supply elasticities, 0.10 in the short run and 0.80 in the long run for decreasing prices, and 0.15 in the short run and 1.5 in the long run for increasing prices; demand elasticities, of -0.3 in the short run and -1.0 in the long run; and annual average shifts in the supply and demand functions due to nonprice variables, 1.0 and 1.5 percent, respectively.

Within reasonable bounds of the above parameters, agriculture has the ability to remain economically viable during the 1970's under policies to divert from commercial markets about 6 percent of potential farm output coupled with direct payments of up to $4 billion annually. With prices paid increasing more rapidly than prices received, the quantity supplied tends to be restricted and thus net farm income decreases less through 1980 if the price elasticity of demand for farm products is under -0.3 in the short run and -1.0 in the long run. Returning to a free market immediately or gradually by 1980 would place severe financial strain and adjustment pressure on the farm sector. A one-shot return to a free market, if it had occurred in 1970, would find a less depressed agriculture by 1980 than would a gradual return to a free market. But the severe short-run impact of the one-shot return seems to rule it out as an acceptable policy alternative.

Given the supply and demand parameters specified above and a continued policy to divert about 6 percent of potential production, the parity ratio would fall 6 points by 1980 and net farm income would decrease to $14.7 billion, compared with $16.5 billion in 1969. A gradual return to a free market would result in a 4.8 percent reduction in the parity ratio relative to 1969 and net farm income would decrease about 50 percent to $8.4 billion in 1980. Net farm income would be $6.3 billion less by 1980 under a gradual return to a free market than under a continuation of the present program.

It is beyond the scope of this paper to analyze adjustments by commodity groups and regions. The aggregate analysis reported herein provides useful insights only into the economic viability of the farming industry. While analysis of commodity sectors and regions would be desirable, opportunities for substitution permit at least short-run disparities in the economic health of one sector or another without any real insight into the economic health of the aggregate as reported in this paper.

Knowledge of the overall economic health of the farm industry is vital for policy planning. Two general approaches may be used to gain needed information. One is the aggregative approach used in this paper. A second is a disaggregate approach, building aggregate estimates up from studies of component crop and livestock sectors. Inability to quantify substantial opportunities for substitution among commodities in production and consumption preclude realistic aggregate results from micro studies. On the other hand, it may be feasible to anchor microeconomic projections in the aggregative projections of this study. An analysis of adjustments over time by commodity group, region, and farm class would clearly be desirable and a logical extension of the aggregate estimates contained in this study.

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Footnotes

[1] Italic numbers in parentheses indicate items in the References.

[2] Socially acceptable prices here refer to prices farmers receive for farm-produced commodities. They are generally market or Government support prices but also could be defined to include Government direct payments to farmers.

[3] This definition of, and technique for measuring, excess capacity does have some shortcomings. First, data on some diversions of the kind included in this definition are unavailable or insufficient to include in our estimates. Second, farmers' inability to organize production at the optimal level and least-cost combination of production inputs is another kind of excess capacity. Tyner and Tweeten (*7*) estimate that this latter type of excess capacity is approximately equal in dollar value to excess output. But excess capacity due to less than optimal resource combination is internal to agriculture and would be present, perhaps even to a greater extent, in the absence of Government programs. Thus excess capacity, as estimated in this study, is an adequate and operational measure of the farm sector's ability to adjust to changing economic conditions with and without Government programs.

[4] The aggregate supply elasticity reflects adjustments of livestock and crops to changes in prices received by farmers. The slow adjustment for livestock largely explains the greater magnitude of the elasticity in the long run than the short run. An alternative approach to that used in this study would be to estimate crop and livestock excess capacity separately and apply respective elasticities. To determine aggregate effects, cross elasticities could be used to bring the sectors together. We rejected this approach because cross elasticities have never been estimated with acceptable reliability, and we have more confidence in estimates of the aggregate elasticities than in individual crop and livestock components.

[5] The supply and demand functions are linear in logarithms. For the supply function, (1), Q_t is the quantity supplied in year t. a_s is the supply constant. $(P/P_d)_{t-1}$ is the price P received by farmers, deflated by the price P_d paid by famers for production inputs in year t-1. β_s is the short-run supply elasticity. The coefficient $(1-\delta_s)$ of the quantity supplied in year t-1 specifies an adjustment rate δ_s, where the long-run supply elasticity is equal to β_s/δ_s. The exponent $g_s(1-\delta_s+\delta_s T)$ for the base of the natural logarithm (2.718) is required to maintain a constant shift in supply over the short- and long-run adjustments to time, T. Coefficient g_s is the annual percentage increase in the quantity supplied due to nonprice variables.

The demand function, transposed in (2) to make P the dependent variable, is specified similarly to the supply function with corresponding parameters subscripted with a d to denote demand.

[6] Using data from the Farm Income Situation, marketings net of interfarm sales are deflated by the index of prices received by farmers and production expenses net of interfarm sales are deflated by the index of prices by farmers. The resulting ratio of real production expenses to real marketings actually decreased from 0.67 in 1951 to 0.57 in 1969. Thus, the historical increase in production expenses was due to output expansion and input-price inflation, and not to increases in real purchased inputs relative to real marketings.

[7] Interfarm sales are assumed to equal 25 percent of purchased seed plus 50 percent of purchased feed plus 75 percent of purchased livestock. In 1969, interfarm sales amounted to $6,621 million, realized gross farm income excluding Government payments totaled $50,804 million, Government payments were $3,794 million, and production expenses were $38,064 million. Net farm income, equal to gross farm income including Government payments minus production expenses, was $16,534 million (*11*, p. 44).

[8] The results apply more generally to a situation in which the shift to the right in demand exceeds that of supply by 0.5 percentage point annually. The demand and supply parameters specified above were the most reasonable choices, based on results from previous studies in which a wide range of estimates were considered. Also, these parameters provide the most reasonable set of outcomes in results of the simulation model reported herein.

The Role of Competitive Market Institutions[1]

By Allen B. Paul

Continuous reorganization of markets is implied by the process of economic growth, wherein specialization, enlargement of scale, and applications of technology keep marching onward. Under a regime of private property, there are continual adaptations of different means for mobilizing capital that are more or less appropriate to different situations—means that mitigate the hazards of loss to the individual or firm. In agriculture, a host of enterprise-sharing arrangements have developed. These should be separated into ones that result in meaningful market prices and ones that merely divide up the residual rewards. A number of market tendencies and problems are noted.

Keywords: Competitive market; Competition; Economic growth; Contracts; Forward trading; Futures trading; Joint accounts.

The state of competition in agricultural markets seems to require continued study and debate. This paper explores the role of competitive market institutions in the agricultural sector in the context of economic growth—a vantage point that deserves more attention.

Different Theories of Markets

The usual approach to the study of competition uses models grounded in static equilibrium theory. One need not argue that agricultural markets are or ever have been competitive in the usual textbook sense to find such models useful. They often guide analysis through the economic maze of commodity markets and offer good results (*3*).

But for our purposes, the nature of competition and pricing, and the problems they pose, probably can be understood better in the context of economic growth and market expansion. We are concerned with markets in disequilibrium rather than equilibrium. Such disequilibrium is an essential feature of an expanding economy. We seek a continuous process by which change in market organization is generated. The assumptions of static equilibrium theory do not lead us down this path.

The processes of economic growth are complex and somewhat intractible to analysis. Yet one outstanding trait suggests an insight. Viewed over a long period, economic growth under a regime of private property has shown a momentum of its own. Kuznets (*9*) concludes that over the past century, the real product of the non-Communist developed countries has increased 15-fold; per capita product, 5-fold; and population, 3-fold. These rates are general and they seem far in excess of anything that had occurred in earlier centuries.

The momentum of economic growth can be partially understood in terms of the continuous unfolding of scientific discoveries, the cumulation of the stock of useful knowledge, and its widening applications. Yet scientific knowledge had been accumulating in earlier centuries without dramatic effects on economic life. Why? According to Hicks (7), increases in the level of real wages came only after machines could be made by other machines rather than by hand. This set in motion a process of continual improvement in the quality of machines and a lowering of their unit cost. Thus more and better machinery could be supplied without additional savings out of current income. Wage earners could garner the fruits of technological advance and therewith provide a continually growing market for output.

The Process of Market Reorganization

Whatever the merits of this explanation of sustainable growth, our interest here is in the reorganization of markets that is implied by such growth. The reorganization must occur on two levels, one "real" (commodities, machines, land, labor), the other institutional (customs, procedures, rules and regulations affecting property ownership and exchange).

Growth implies a continued reorganization of production by more efficient methods. The lowering of unit costs in an industry is associated with expansion of its output, or release of resources to other industries. As one industry expands, it therewith furnishes a larger market for the output of other industries, which then find it feasible to further rationalize their own produc-

Notes are at the end of the article.

tion. The latter industries either grow or release resources. If they grow, they furnish enlarged markets to still others. If not, the released resources enter other employments and expand output. And so the process feeds on itself with potentials for specialization, economies of scale, and applications of technology to become heightened in various places. Industry after industry becomes caught up in the need to modernize, write off old equipment, retrain personnel, make different products, and so on—or it will eventually decline.[2]

The process of growth exposes the individual (or firm) to large hazards. Encroachment on his economic opportunities may arise from substitute products, processes, or modes of business. When this occurs, he must consider whether to further specialize, invest in new equipment and knowledge, or change activity.

Big firms may have more staying power but they do not escape. On such issues Galbraith (4) concluded that the competitive market is obsolete. Market uncertainties are intolerable to the firm that must carry out a technically difficult and costly set of operations to bring its products to market. Instead, the firm must decide on a price line and then hold to it, if necessary, by more promotion and advertising.

There is some validity to this view—even in the food industry—but it can be misleading. Big firms are not as much in control of markets as this view supposes. A mechanism is needed to insure consistency of individual plans. This is what market prices are about. It would be quite accidental that each firm could by itself decide on the right price for its output and hold to it for long. Even acting jointly they may not do well. The biggest economic units—national governments—have suggested this by abandoning fixed currency values in favor of floating values. It is possible that they are not in sufficient control of basic economic forces, nor able to predict them well enough, to set a price line that will hold for long. The more financial reserves at the command of the firm, the longer it can hold to its price. But sooner or later it will divert products to less profitable outlets, deal off list, offer more for the money, reset its schedule of prices, or lose out to other firms that do so.

It may now be evident that here we attach another meaning to competition than that given in static equilibrium theory. We recognize that many firms have some degree of market jurisdiction (socially acceptable or otherwise) but do not imply by this that they necessarily have strong control over their destiny. In this sense a competitive market is one in which the forces over which a firm has no control greatly exceed those over which it has control. Here, trade occurs largely at prices that the firm must sooner or later accept.[3]

The principal technique for individual survival is to divide up the financial commitment to any hazardous undertaking and share it with others. The preponderant share of one's capital ordinarily must not be tied up in one venture. The larger the scale of production, the more capital is required, hence the more urgent the need to devise suitable ways to spread out the economic responsibility in order to mobilize the necessary capital.

There are two separate though not mutually exclusive routes to mobilize capital through enterprise sharing. One, of course, is the pooling of sufficient capital under the command of a single economic unit to survive the most hazardous ventures that the managers may elect. Syndicates, partnerships, and corporations—in their various forms—are the main arrangements. Cooperatives, for example, are partnership or corporate units whose distinguishing mark is that residual rewards go primarily to (or are reserved for) patrons of the enterprise who also are its main owners.

The other route is to bind sufficient capital to a specified course of production by voluntary agreements among sovereign economic units. Joint-account production, contract farming, forward purchases, participation agreements, and organized futures trading are the usual instruments. It is beyond the scope of this paper to compare the merits and survival power of the two different routes for mobilizing capital. I only need to point out that any deal between two sovereign economic units implies that a mutually determined exchange has occurred. In the real world, this is what a market is about, whatever its complexities, strengths, or deficiencies.

In addition to the emergence of these private market arrangements for mobilizing capital, various public means have emerged for fostering investment—price and income supports, tax concessions, underwriting of loans, and so forth. Indeed, the Employment Act of 1946, declaring that it is the continuing policy of Government to promote maximum employment, production, and purchasing power, as much as anything signaled the beginning of wider public acceptance of responsibility for mitigating pervasive economic hazards.

Both public and private means for mitigating hazards of loss have this in common: They amount to a "pooling of risk." But there is an important interaction between them. The more public assurances that are devised, the more the encouragement to private investment for new products, processes, or modes of business wherein there are hazards specific to the undertaking. Put another way, the pursuit of the untried is encouraged by freeing of venture capital from financing projects that now appear sure-fire, by substituting loan capital.[4]

This appears to lead to an interdependent process on

the financial side which is one of the self-reinforcing mechanisms of economic growth: Private ventures into new realms promote the growth of output, growth of output tends to promote the spread of public measures that allow more individuals to escape big economic hazards, and this, in turn, tends to promote more private investment in new realms.

Status of Competitive Pricing in Agriculture

What is new about present contractual arrangements in the agricultural sector? Historically, many of these arrangements were responses to the desire of dealers or processors to assure supplies needed in their daily businesses, like fresh vegetables needed for canning and fluid milk for bottling. These perishable items could not be stockpiled nor distantly transported. Under binding agreements, one party, in effect, hired another to do a specific job.

Even items that could be shipped long distances were not always available as needed. Hence various contractual arrangements arose early to assure the supply. Wells Sherman (*19*), writing in 1928, noted that every vegetable growing region of importance which had to ship any considerable distance to market was financed by large dealer advances. He noted that the bulk of the money to produce the enormous canteloup crop of the Imperial Valley had always been supplied through shippers and handlers, the Colorado Mountain lettuce industry was stimulated and fostered by dealers who financed production and marketing, Mississippi tomatoes were financed as cotton was formerly financed, and about 40 percent of the money needed to produce the 1926 early potato crop came from distant sources through the hands of dealers to growers.

Evidently dealers had an advantage over bankers in financing production because they could spread the risks over a wide range of products, seasons, and localities. The banks could not. The financing was either part of a joint account or an advance purchase arrangement with growers to produce the commodity. In the latter case, the dealer agreed to take the crop at a fixed price per unit of a given grade and to make certain payments in advance, or at different periods of its growth or maturity, or for specific expenses. In any case, dealers were motivated to develop arrangements with growers in distant regions to assure themselves of constant supplies for eastern markets.

Such arrangements tend to change with the times. Today more contracts in fresh vegetables for market are in evidence between growers and shippers than between growers and eastern dealers. Besides vegetables, contracting with farmers for output historically appeared in other commodities, especially though not exclusively during the early stages of their expansion—for example, cotton or soybeans. Each has its own interesting set of circumstances.

What appears to be new about some contract arrangements is their ability to spread decisive cost-cutting methods. This role goes well beyond the usual one, arising from enterprise sharing, that permits production to be organized on a more efficient basis by enlarging the scale of the individual unit and applying more machine methods. Rather, we have seen, especially in the poultry industries, a very rapid push of biological breakthroughs, via closely supervised production contracts. Because of a favorable economic setting there was a major restructuring of production in a short time.

Many thoughtful people have entertained the proposition that such revolutionary changes in business methods for producing broilers are the wave of the future for other commodities. Protagonists still can be heard on both sides of this issue. To get my bearings, I have found it instructive to view all of animal agriculture, except dairy, in cross section. One can compare the recent share of U.S. output of each industry—cattle, hogs, sheep and lambs, eggs, turkeys, and broilers—that was produced under closely coordinated arrangements with the amount that farm prices for the commodity had declined from 1947 to 1970. This is shown in figure 1.[5]

Despite deficiencies of data and method, the strong negative relation suggests that cost reduction was the driving force behind the spread of these closely coordinated arrangements and, moreover, that effective price competition had prevailed despite market imperfections.[6]

It suggests that such closely coordinated arrangements could come in elsewhere rapidly, if important economies could be realized, although it is not clear that cattle, hogs, and sheep are the most likely prospects. Engleman (*18*) has long argued against hogs soon going this route, and his reasons still sound plausible.

There are few permanent reasons for present contract arrangements. Production and financing advantages, however great, can prove transitory. Technical knowledge is transferable: so are the alternative sources of capital. Except for cultural lag, tax advantages, or other subsidies, a particular organization for commodity production will survive as long as it satisfies the basic problems of production and investment as well or better than other arrangements.[7]

More than a decade ago. I noted that forward buying and selling of broilers might serve about the same purpose as contract production of broilers, wherever the latter provided for sharing of the enterprise responsibility (*14*). Today we see the beginnings of activity in

RELATIONSHIP BETWEEN SHARE OF U.S. OUTPUT UNDER CLOSELY COORDINATED PRODUCTION AND CHANGES IN AVERAGE PRICES RECEIVED BY U.S. FARMERS

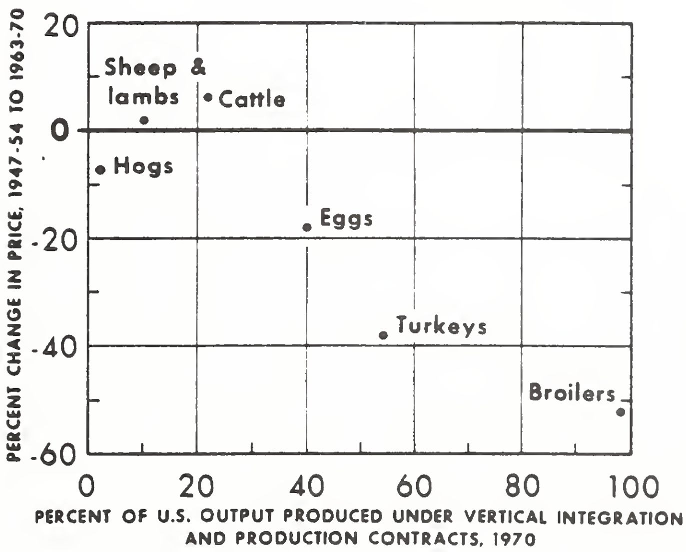

Figure 1

formalized buying and selling of broilers for forward delivery under the aegis of organized futures trading.[8] The same thing has happened for fed cattle and hog production. Contract production (called "custom feeding" in the cattle industry) and hedging in live cattle and hogs in futures are institutional substitutes (*13*).

Space does not permit analyses of such institutions of trade. But it is important to note that the expanding economy has served up a new requirement, namely, the need to develop more effective ways of pricing services. These services are produced by someone as a selected enterprise and used by another who decides that a commodity will be forthcoming, but does not wish to be involved in actual production.

Thus, the types of services that are now bought and sold are legion and they result in commodity transformations in form, place, and time. This is where one should look for the meaning of the secular rise of organized futures trading, forward dealing in "actuals," and contracting for the services of growing, processing, transporting, and storing commodities.

There is developing a broad-gaged market in the pricing of services, but one that is not readily perceived nor often correctly interpreted. The problems of pricing arising in this context are varied and include, among other things, the need for more reporting of prices for services—for example, poultry contract prices and other terms; custom-feeding charges and other terms; and prices for an increasing number of other operations performed for others in the growing, assembly, processing, and distribution of commodities.

Some Market Tendencies and Problems

The growth process, as we have described it, depends on the rise of markets. Hicks has made this point the central feature of his book, *A Theory of Economic History* (7). However, many problems of markets arise because of the very growth that markets foster. Institutions of trade tend to get out-of-date because products, processes, modes of organization, and ideas of property change. The lag in adjustment causes distortions and inequities that might be relieved through conscious effort.

There is obsolescence of grading factors, inspection methods, packaging, contract terms, financing and insurance methods, and techniques for searching the market, negotiating transactions, and redressing grievances. Also, public tolerance for negative external effects of economic processes is not constant, as recent experience teaches.

Economists could be busier than they are in clarifying the issues, measuring costs, and suggesting improvements. It probably would be a good use of their time. The problems are much too big to discuss here. Rather, I will abstract from these issues and discuss, instead, two general tendencies in markets for agricultural products that cause general concern.

Increasing dispersion of price structure. Growth signifies more variety of goods and services. More considerations of value arise because buyers now find shades of difference in time, place, and form (as well as options and guarantees) to be important, and sellers now find more ways to specialize output and vary offers. This could create more problems of arbitrage, wherein price differences should be brought into line with costs of implied commodity transfers. The larger number of prices tends to enlarge the task of acquiring information about offers and performance guarantees. Hence, there could be a widespread tendency for prices of different variants of a commodity or service to move independently.

Professor Stigler said that markets should not be faulted for this. Thus if it costs, say, $25 per lot to search the market for a better offer, then prices in different parts of the market may trade as much as $25 apart without any sacrifice (*20*). There remains a question as to whether the necessary information could be obtained for $5, through some arrangement. How serious this matter is in markets for agricultural products is an empirical question.

Each participant need not incur the cost of searching

the entire market as long as there are overlapping patterns of search. Conceivably each participant need canvass but one or two alternatives. Competition would force prices well into line across the market wherever the marginal cost of search was quite small. This result might not hold where buyers were few, but this is a matter of monopoly and not the costliness of trading.

We also need to know more about how markets actually function in related respects. For example, the role of terminal markets continues in doubt. No one seems to know how "thin" a central market can become before its use as a pricing base to settle contracts distorts pricing throughout the system.[9] The tendency is to infer performance largely from the numbers, size, and behavior of firms. Among other things the number count is sensitive to where the economic boundaries of the market are drawn, and these seldom conform to the boundaries of terminal markets. One needs to analyze the interaction of prices—farm, local, terminal, spot, forward, and so on—that are established throughout the entire system. We do have some studies of this kind (*2*, *6*), but too few to narrow appreciably the area of debate.

Even some of the simpler pieces of information would be helpful. For example, the rise of retail chains that buy produce directly at country points has been well noted. Yet probably in the aggregate well over one-half of the fresh fruits and vegetables moving to market in the United States still are sold in the cities by wholesale receivers or brokers via private treaty or auction (*22*). Buyers are retailers, restaurants, institutions, Government agencies, and intermediates themselves. The aggregate figure has been stable for the last 5 years but has varied between cities and commodities.[10]

We also need more insight into the pricing of contracts with growers for supplying commodities for processing. Are there different prices to different growers in a region? If so, do these represent differences in what is being contracted for? If terms offered are uniform, are they the most suitable to different growers' needs? When there are complaints, it should be possible to document pricing and other practices as a basis for an assessment and a search for remedies.[11]

Increasing vulnerability of firms to price changes. Increased specialization of production tends to decrease the elasticity of supply because equipment and skills tend to become highly specialized and less mobile. Other things equal, the greater the specialization, the more unstable the returns. The relevant price spreads become narrower and given percentage changes in price for commodities bought and sold can cause a larger percentage change in returns.

The instability is compounded wherever there is decreasing price elasticity of demand for a product—as a result of its becoming a smaller item in household budgets or having fewer substitutes as an intermediate good.

Yet specialization in food and agriculture has proceeded in the face of such an adverse setting. It has done so by finding ways to lessen exposure of the firm to loss as noted earlier. Public measures, such as surplus removal, price support, supply management, and deficiency payments, have been called into play. Apart from these, the search has been for various enterprise-sharing arrangements that are suitable.

The full range of such instruments can be seen today, for example, in the U.S. cattle feeding industry, wherein syndicates, partnerships, corporations, contract feeding, and forward contracts for feed, feeder cattle, and fed cattle are simultaneously in evidence. What are the issues and problems?

There are difficult problems of valuation under any arrangements where different interests participate in a given course of production. A distinction should be drawn between agreements that create meaningful prices and those that do not. In the case of cattle feeding, meaningful prices are established for a set of services to be produced by one party for another (through custom feeding, or through hedging in futures).

While the agreed price determines in large measure the sharing of returns from cattle feeding among the parties, *it also provides a significant message to other firms contemplating a similar course of production.* On the other hand, a partnership agreement between two or more parties to feed cattle provides only a formula for sharing the returns. By itself, the agreement is not necessarily significant to anyone else who might contemplate feeding cattle. Yet the two methods of limiting exposure of the parties are substitutes, as noted earlier.

Any formula for sharing returns is important to the participants. Its performance affects the durability of the agreement. Landlord-tenant agreements in farming have evolved over the centuries (indeed, residual-sharing agreements probably antedate the market system itself, being governed by rules of traditional society). What seems new today is the effort by larger commercial units which assemble, process, or distribute products, to enter cooperative agreements with each other for mutual benefit (*5*). Here the range in which terms can be fixed more favorably to one party than to the other, without either party pulling out of the joint agreement, can be large indeed.

Whether particular terms of a partnership affect resource use requires study of the facts of the case. Wherever efficiency implications are minor, equity becomes the main basis for appraisal. Any problems come

down to the distribution of power, and what can and should be done about it. Antitrust action is one possibility and collective bargaining the other. Each has its effective uses. The subject is too big and difficult to deal with here.

One should also explore the empirical conditions that simultaneously foster partnership agreements and deter the market in providing ways of sharing enterprise. Thus, farmers and processors often enter into various agreements to share the residual reward where either or both of the parties undertake a long-term investment. They seek to assure supplies or outlets, and coordinate effort at each level, for both to be successful. Examples appear in the production of sugarbeets, tree fruits, grapes, broilers, and shell eggs. Are these commodities whose technical conditions (such as perishability or bulkiness) limit how far the competitive market could develop its own enterprise-sharing techniques?

Put another way, under what conditions, if any, can we expect an institution of the competitive market to thrive in a highly integrated, highly concentrated, or otherwise imperfectly competitive industry and thereby broaden competition? I once thought this question was a contradiction of terms; now I am not so sure. Wherever there are latent competitive elements (often the case in agriculture), easier access to the market may bring them out. Something like this caused the breakdown of cartelization of the copper market by the rise of organized futures trading in copper. With organized futures trading recently being imposed on new commodity areas—like frozen concentrated orange juice, fresh eggs, and iced broilers—we soon may have opportunities to sharpen our insights into the role and suitability of the different types of market and nonmarket arrangements for subdividing enterprise responsibility and mobilizing resources for a given course of production.

Of course there are other ways to promote competition apart from trust-busting or installation of organized futures trading machinery. These include updating of the institutions for the conduct of modern business—such institutions as commodity grades, inspections, price reporting and other market information, means of borrowing, contract security, the laws and regulations respecting fair dealings, the use of patents, and so on. These are the great body of arrangements that facilitate access to economic opportunity and that need serious attention.

Indeed, with modern electronic technologies, the capacity for one individual to get in touch with another is better than ever. A great challenge is to exercise our imagination on how to effectively use the powers of industry and governments to realize the potentials for improved trading arrangements.[12]

Closing Observations

This paper has dealt with economic growth in relation to the progressive reorganization of markets. We have not stopped to examine the limits to growth and to learn how an increasing anticipation of such limits might direct conscious efforts to reorganize economic life. This subject lies beyond the scope of the paper.

A short summary of the underlying process of growth that has guided our inquiry is this: Specialization of production (with attending enlargements of scale and further applications of technology) marches on in a growing economy, as both a cause and a consequence of growth, but at no faster pace than permitted by the reduction in investment hazards through public and private techniques, which techniques are themselves a cause and a consequence of economic growth.

Ways are always being sought to mobilize capital in the face of increasing hazards to its owners. The nature and meaning of complementary and competing institutions for ownership—partnerships, pools, syndicates, corporations, cooperatives, forward commodity dealings, production contracts, and organized futures trading—may be made intelligible in this context. One should distinguish between those that are instruments of exchange and thereby influence market adjustment, and those that are not.

In this context, there has been much misunderstanding of the role of bilateral contracts. All fixed-price contracts, and some formula contracts, for a commodity or a service to transform the commodity, are true instruments of exchange. A contract signifies that an interval of time exists between transaction and performance. Except for "cash-and-carry" deals, as in grocery stores, restaurants, and taxicabs, all buying and selling of goods and services at any level denotes dealing in contracts. We should be able to identify what it is that is bought and sold in any contract, despite complexity. Then we could investigate barriers to arbitrage between the different kinds of claims to the same commodity or service. This is important because it is the possibilities of arbitrage that tie the activities of the different participants together into a unified market process. We might then be better able to understand market behavior and identify sources of market failure.

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Notes

[1] This article is based on a paper presented in August 1973 at the University of Alberta meetings of the American Agricultural Economics Association, the Western Agricultural Economics Association, and the Canadian Agricultural Economics Association, Edmonton, Canada.

[2] These ideas are rather compressed in their presentation here. Another way to suggest the central thesis in even briefer form is that growth begets specialization which begets growth (*25*).

[3] In general the definition of competition still appears to be unsatisfactory. See Morgenstern (*12*).

[4] This substitution is hard to observe in cases where the business firm avoids borrowing and draws upon retained earnings instead. But then the return on much of the business's equity would approximate the market rate of return on loans.

[5] Price data are from *Agricultural Statistics* (*21*) and production data from Mighell and Hoofnagle (*11*).

[6] There is no explicit model underlying the relationship shown. Were data available, one could employ a model that contained two supply response equations—one for the closely coordinated sector and one for the remaining sector.

[7] Alchian and Demsetz (*1*) recently followed out this thought in explaining resource allocations within the firm (in contrast to allocations between firms). They view the firm as team production, held together by a special class of contracts between the various joint input owners and a central party. Accurate assessment of productivities of individual inputs is very difficult and a large reward goes to "monitoring and metering" inputs among usages, mainly by detecting shirking—a task that can be achieved more economically within a firm than by across-market bilateral negotiations among input owners. Yet they recognize that the problem of policing inputs might be best solved in such cases by bilateral market contracts that call for farm inspections. (They cite the case of a farm commodity whose subtle quality variations can only be detected by inspecting the growing conditions.) Thus, each set of productive circumstances may have its own best type of contractual solution, either within the vertically integrated firm or across the market in some type of bilateral contract specifications.

[8]It is fairly obvious why nearly all fresh vegetables for processing must be grown by a vertically integrated processor, or under closely coordinated production contracts. The technical conditions—quality, perishability, seasonality, and bulkiness—offer little choice. But for most commodities, it is not obvious why existing arrangements—whatever they happen to be—must persist.

If today broiler producers do not have outlets for their live birds, except by entering into production contracts, this lack of outlets might reflect monopsony in processing without necessarily reflecting immutable conditions of broiler supply. One can visualize some broiler producers who understand how to care for birds, entering into forward delivery contracts rather than production contracts, with processors. The latter, in turn, might sell iced-broiler futures—thus assuming the role of hedging intermediary or, more accurately, the seller of processing services. An orderly flow of birds to slaughter could be preserved by giving the processor some delivery options. Alternatively, one can even imagine greater use of toll processing for the account of the grower or retailer

Such developments would imply several things. First, in the maturing phase of the industry, it would no longer be especially attractive for the processor to be a partner in producing broilers. Second, the broiler producer would have achieved a sufficient level of size and sophistication to accept managerial responsibilities abdicated by the processor. Third, the market would offer the grower the necessary range of services, including loan capital, to carry forward a modern broiler-growing operation under the aegis of forward selling.

One need not predict that these conditions will emerge on a substantial basis. But they appear feasible after some threshold of market expansion has been breached.

[9]The criterion of market "thinness" often is equated with fewness of transactions. This in itself can lead to mistaken interpretations. More important is the volume of latent bids and offers, that would result in greater volume at the terminal market should anyone choose to raise or lower the going market price by committing the necessary capital.

[10]The survey figures for March 1972 show that under 20 percent of all arrivals of fresh produce in Boston went directly to chainstores, whereas over 60 percent did so in Washington. The weighted average for 23 main cities is 34 percent. The average figure in the original survey by Manchester (*10*) was somewhat lower.

[11]While these are costly studies to make, various studies along these lines have been made (for example, *8*, *15*, *17*, *23*).

[12]A recent start in such directions is revealed in reports of several USDA Marketing Teams (for example, *24*).

ECONOMIC CONSEQUENCES OF FEDERAL FARM COMMODITY PROGRAMS, 1953-72

By Frederick J. Nelson and Willard W. Cochrane*

Farm programs of the Federal Government kept farm prices and incomes higher than they otherwise would have been in 1953-65, thereby providing economic incentives to growth in output sufficient to keep farm prices lower than otherwise during 1968-72. The latter result differs significantly from findings in other historical free market studies. These conclusions stem from an analysis of the programs in which a two-sector (crops and livestock) econometric model was used to simulate historical and free-market production, price, and resource adjustments in U.S. agriculture. Supplies are affected by risk and uncertainty in the model, and farm technological change is endogenous.
Keywords: Government farm programs, farm income, risk, technological change, free market.

THE OBJECTIVE

Policy decisions affecting future production, consumption, and prices of food and fiber in the United States need to be made with as full knowledge as possible of the likely longrun and shortrun consequences. The quantitative analysis of past farm commodity programs described here can provide useful information for analyzing the consequences of future alternative programs.

How would agricultural economic development in the United States have been different if major farm commodity programs had been eliminated in 1953? To help answer the question, an econometric model was set up to simulate the behavior of selected economic variables during 1953-72.[1]

Farm programs of the Federal Government have, in various ways, supported and stabilized farm prices and incomes since 1933, when the first agricultural adjustment act was approved. Since then, dramatic long-term changes have occurred in (1) the resource structure of agriculture, (2) the productivity of measured agricultural resources, and (3) agricultural output levels. Such long-term changes did not occur independently of the farm programs. These programs were operated in a way that reduced risk and uncertainty for farmers, affected their expectations of future income potential from farm production activities, and influenced their willingness and ability to invest, to adopt cost-reducing technology, and to adjust output levels.

In considering effects of the programs, it is desirable to specify a model in which shortrun and longrun agricultural output responses are affected by investments, current input expenditures, and farm technological changes. These, in turn, should be influenced by price and income expectations and experiences, by the extent of risk and uncertainty, and by technological change. Such ideas were used in developing this model. A unique feature of the model is that it includes endogenous risk and resource productivity proxy variables.

Not much quantitative knowledge exists about intermediate and longrun supply adjustments under a sustained free-market situation. No claim is made however, that this model's results represent the definitive word in free-market analysis of the period studied. The estimates of longrun and shortrun effects of farm programs are extremely sensitive to changes in several assumptions that affect total supply and demand elasticities in the model. Further, ordinary least squares regression analysis (OLS) was used to estimate the coefficients of behavioral equations. Thus, the results should be considered preliminary and subject to revision if alternative estimation techniques later reveal substantial differences for important coefficients.

A central feature of the model—the disaggregation of agriculture into two sectors, crops and livestock—can be seen as both an advantage and a limitation. Use of two sectors instead of only one does allow analysis of important interrelationships between crops and livestock over time. But future research efforts should be aimed at a further extension to include specific commodities for two reasons. First, persons and organizations that might be the most interested in the type of information available from the model would want answers for specific commodities. Second, commodity specific equations might provide more accurate quantitative results. For example, measures of price variability for each commodity are the most logical proxy measures of the

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[1] A number of agricultural sector-simulation models developed in recent years can be used to quantify the total impact of farm commodity programs. Some of these models were reviewed in this study (*3, 8, 23, 24, 26, 30*). The basic framework for this model resembles that in (*30*) and in (*24*). However, following Daly (*2*), a two-sector approach was used instead of the one-sector approach of Tyner (*30*) or the seven-sector method of Ray (*24*).

extent of risk and uncertainty. But they were not used in the two-sector model.[2]

THE MODEL: ANALYTICAL FRAMEWORK, THEORY, AND SIMULATION PROCEDURE

The analysis centers around a comparison of two simulated time series for each of several variables in 1953-72. One series shows estimates of the variables' actual historical value with programs; the other, estimates in a free market without programs. The impact on a particular variable is the difference between its historical and free-market values, shown as a percentage change in table 4 and figure 1 (see p. 59).

As a measure of alternative impacts possible, several simulation results were obtained, based on differing assumptions about demand elasticities and resource adjustment responsiveness in a free market. This provided a test of the sensitivity of the model's results to such changes. Detailed discussion is limited primarily to one simulation set.

Overview

The simulation model consists of 59 equations (33 identities and 26 behavioral equations) and contains 51 exogenous variables.[3] A resource adjustment approach to crop and livestock output and supply response was used in designing the model. The simulation procedure for each year is as follows (the calculation for 1953 is used as an example):

- Current input levels are determined for the initial year (1953) based on beginning-of-year asset levels, current and recent price and income experiences, and farm programs in use
- Crop productivity and production are determined endogenously, based on the level and relative importance of selected inputs assumed to be primarily used for crop production
- Crop and livestock supply and demand components (including livestock production) and prices are simultaneously determined once crop production is known and Government market diversions under the farm programs are specified
- Given the above results, the model computes various measures of income, price and income variability, and aggregate agricultural productivity.
- Asset, investment, and debt levels, number of farms, and farmland prices are adjusted from the previous end-of-year levels, based on 1953 and earlier price and income experiences
- The above results are used to make similar calculations for 1954 and later years given the complete time series for those explanatory variables not determined within the model.

The data used to measure the variables are based on published and unpublished calendar year information from the Economic Research Service, and the Agricultural Stabilization and Conservation Service in the U.S. Department of Agriculture. However, only a few of these variables are published in the exact form used here. To facilitate analysis, assets, inputs, production, and use statistics were measured in 1957-59 dollars; for price indexes, 1957-59 equal to 100 was generally used.

Farm Program Variables

The farm programs covered include those involving price supports, acreage diversions, land retirement, and foreign demand expansion. Programs involving domestic demand expansion, marketing orders and agreements, import controls, and sugar are not explicitly included. The programs included have affected agriculture in the past two decades by:

- Idling up to 16 percent of cropland (6 percent of land in farms) through programs involving long- and short-term acreage diversions to control output
- Diverting up to 16 percent of crop output from the market into Government inventories or subsidized foreign consumption through price support and demand expansion activities
- Providing farmers with direct Government payments equal in value to as much as 29 percent of net farm income (7 percent of gross income).

Table 1 contains values of the exogenous farm program variables used. Table 2 shows the relative importance of some of these variables in the crop sector. The following three sections explain more about use of these variables and indicate the level for each program variable in the free-market simulation.[4]

[2] Ray's disaggregation approach (*24*) is one alternative. Separate resource adjustment equations and production functions are included for livestock products, feed grains, wheat, soybeans, cotton, tobacco, and all other commodities. However, a procedure that places less strain on the available data would be one that uses commodity acreage and yield equations "controlled" by simulated aggregate resource and resource productivity adjustment estimates. See (*22*, p. 10; *34*).

[3] For a complete discussion of the theory, model, data, and simulation procedure, see (*19*). This information will also be available later in a planned USDA technical bulletin. A description of the variables and a list of the actual model equations are available from the senior author on request.

[4] An argument can be made in favor of making some or all program variables endogenous. For example, CCC inventory changes and acreage diverted by programs are complicated functions of announced price supports (loan rates), diversion requirements, and other supply and demand variables. Thus, exogenous price supports, instead of exogenous CCC inventory changes, could be used to represent the price support through acquisition and disposition activities of the CCC (as in (*3*)). Further, one might want to specify only policy goals (such as net income) as exogenous so that program operation rules would need to be endogenous to determine program details each year in

Table 1.—Government farm program variables, 1950-72

Year	Acres of cropland idled by programs (AD)	Percentage of land in farms not idled (PCT)	Percentage of acres planted with hybrid seed (PCTHB)	Net Government (CCC) inventory increases (1957-59 dollars)		Exports under specified Government programs (1957-59 dollars)		Government assisted crop exports (1957-59 dollars) (ASCX)	Direct Government farm program payments (GP)
				Crops (CCCD)	Livestock (CCLD)	Crops (GCX)	Livestock (GLX)		
	Millions	*Ratio*		*Billion dollars*					
1950	0.0	1.0000	0.1900	-0.765	0.035	a			0.283
1951	0.0	1.0000	.1960	-.446	-.122	a		a	.286
1952	0.0	1.0000	.2010	.351	0.0	0.386	a	0.426	.275
1953	0.0	1.0000	.2040	2.164	.315	.369	0.063	.353	.213
1954	0.0	1.0000	.2060	1.028	.127	.531	.127	.319	.257
1955	0.0	1.000	.2130	1.289	-.203	.759	.214	.316	.229
1956	13.6	.9983	.2160	-.312	-.149	1.268	.231	.543	.554
1957	27.8	.9765	.2200	-.919	.051	1.219	.170	.933	1.016
1958	27.1	.9772	.2370	1.350	-.089	.978	.122	.737	1.089
1959	22.5	.9806	.2790	.282	-.031	1.030	.076	.775	.682
1960	28.7	.9753	.2910	.261	.049	1.351	.046	1.098	.702
1961	53.7	.9538	.2490	-.087	.113	1.308	.067	.950	1.493
1962	64.7	.9439	.2570	.191	.172	1.220	.089	.675	1.747
1963	56.1	.9514	.2750	-.016	-.103	1.227	.153	.755	1.696
1964	55.5	.9511	.2590	-.249	-.191	1.377	.176	.935	2.181
1965	57.4	.9500	.2600	-.532	-.031	1.183	.105	.780	2.463
1966	63.3	.9443	.2660	-2.008	-.037	1.214	.063	.923	3.277
1967	40.8	.9635	.2800	-1.192	.143	.920	.108	.783	3.079
1968	49.3	.9561	.2630	1.521	-.011	.870	.116	.528	3.462
1969	58.0	.9477	.2700	1.028	-.061	.711	.093	.550	3.794
1970	57.1	.9483	.2740	-.928	.010	.723	.070	.942	3.717
1971	37.2	.9663	.2970	-.213	-.007	.687	.096	.987	3.145
1972	62.1	.9433	.2740	-.862	-.008	.701	.044	1.137	3.961

[a]Not available or not yet estimated.

Government market diversions. The Federal Government supports farm commodity prices through operations of USDA's Commodity Credit Corporation (CCC). The CCC helps farmers in three ways. It buys or sells commodities on the open market, and extends loans to farmers who have the option of repaying the loan or delivering their commodity to the CCC in lieu of repayment. Also, the CCC encourages domestic and foreign consumption by subsidizing food use or by giving commodities away. Five exogenous variables represent this activity in the model:

- CCCD is net stock change for crops owned by or under loan with the CCC
- CCLD is net stock change for livestock products owned by or under loan with the CCC
- GCX is crop exports under specified Government programs
- GLX is livestock exports under specified Government programs
- ASCX is crop exports assisted by the payment of export subsidies by the CCC

In the free-market simulation, these variables have a value of zero.

Acreage diversions and Government payments. Farm program operations aimed at controlling supply—to reduce the need for costly Government market diversions—include offering farmers some combination of direct cash payments and price support through CCC loan privileges in return for their idling of productive

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the simulation. In the model, however, the procedure is to determine the impact of program operations, not policies, with such operations defined in a special way. The total impact of past program operations is the main goal rather than the effect of selected adjustments to specific annual policy variables or policy goals. See (*19*, pp. 139-149).

Table 2.—Farm program operations affecting crop output and marketings, 1950-72[a]

Year	Total Government market diversions[b]	Total acreage diversions	Cropland plus diversions[c]	Total land in farms	Total crop production	Acres diverted as percentage of: Land in farms	Acres diverted as percentage of: Cropland	Market diversions as percentage of production
	Billion dollars		*Million acres*		*Billion dollars*		*Percent*	
1950	d	0	377	1,202	17.0	0	0	d
1951	d	0	381	1,204	17.5	0	0	d
1952	1.2	0	380	1,205	18.4	0	0	7
1953	2.9	0	380	1,206	18.2	0	0	16
1954	1.9	0	380	1,206	17.9	0	0	11
1955	2.4	0	378	1,202	18.2	0	0	13
1956	1.5	14	383	1,197	18.3	1	4	8
1957	1.2	28	386	1,191	18.0	2	7	7
1958	3.1	27	382	1,185	19.9	2	7	16
1959	2.1	23	381	1,183	19.7	2	6	11
1960	2.7	29	384	1,176	20.8	2	7	13
1961	2.2	54	394	1,168	20.4	5	14	11
1962	2.1	65	396	1,159	20.7	6	16	10
1963	2.0	56	393	1,152	21.5	5	14	9
1964	2.1	56	391	1,146	20.7	5	14	10
1965	1.4	57	393	1,140	22.1	5	14	6
1966	0.1	63	395	1,132	21.6	6	16	1
1967	0.5	41	381	1,124	22.5	4	11	2
1968	2.9	49	384	1,115	23.2	4	13	13
1969	2.3	58	391	1,108	23.5	5	15	10
1970	0.7	57	389	1,103	22.6	5	15	3
1971	1.5	37	377	1,097	25.1	3	10	6
1972	1.0	62	398	1,093	25.3	6	16	4

[a]The information does not represent precise estimates of "excess capacity" in U.S. agriculture, but rather a summary of some relevant magnitudes. These do, of course, have implications for excess capacity analysis. [b]Government market diversions include the sum of net change in Government crop inventories (CCCD), Government crop exports (GCX), and assisted commercial crop exports (ASCX). [c]Includes acres of cropland harvested, crop failure acreage, cultivated summer fallow acres, plus acreage diverted by farm programs (AD). [d]Not available or not yet estimated.

cropland. The acreage idled under annual diversion and long-term land retirement programs (AD) is included as an explanatory variable in the equation for the use of cropland. The associated Government payments (GP) are included as part of gross and net farm income. In the free-market simulation, both of these variables have a value of zero. The percentage of total cropland not idled (PCT) is used in the analysis; its free-market value is, of course, 1.0 (100 percent).

Cropland planted with hybrid seed. The increased use of high-yielding corn and sorghum grain seed has been an important technological advance on American farms. The percentage of total cropland planted with hybrid seed (PCTHB) is used as an exogenous explanatory variable in the fertilizer and crop productivity behavioral equations. It was assumed that the upward trend in PCTHB was retarded in 1956 because acreage-idling programs began that year and they affected the relative importance of corn and sorghum acreage. Therefore, in the free-market simulation, PCTHB was assumed to increase a little faster from 1956 to 1959 than in actual history. The record level of PCTHB for 1971 (0.297) was assumed to have been achieved throughout 1961-72, after the high level achieved in 1960 (0.291.)[5]

[5] Following the theoretical ideas of Griliches (7), one could argue that the percentage of cropland planted with hybrid seed should be endogenous because the corn price level affects the profitability of adopting more expensive, higher yielding seed. An adequate consideration of this question will have to wait until commodity specific extensions are made. The percentage for all cropland depends on the relative importance and geographic location of corn and sorghum acreage as well as on prices received for corn and sorghum.

Special Features

Current input and asset adjustment. Behavioral equations representing the demand for assets were specified assuming asset adjustments occur in response to changes in (1) longrun profit expectations and (2) the extent of risk and uncertainty. Separate equations were included for the quantity of land and buildings, machinery and equipment, and livestock number inventories. The stock of an asset is determined by its level in the previous year, with adjustments for depreciation and for investments. A partial resource adjustment assumption was used in specifying demand equations for assets based on the Nerlovian distributed lag procedure. Longrun demand was explained by including as variables current and recent factor-factor price ratios, relative rates of return to farm real estate, and risk and uncertainty proxy indexes.

Current input expenditures depend on current and recent factor-product price ratios, asset levels, other input levels, and risk and uncertainty proxy indexes. The model contains behavioral demand equations for the following current inputs to agriculture: repair and operation of machinery, repair and operation of buildings, acres of cropland used for crops, fertilizer and lime, crop labor, livestock labor, hired labor, and miscellaneous inputs. The use of "other" input and asset levels as explanatory variables in current input demand functions is consistent with traditional profit-maximizing theory, because the marginal product of one factor depends on the quantity used of other factors. In the short run, current inputs adjust toward longrun levels as asset adjustments occur. Use of other current inputs as explanatory variables in the input demand functions resulted in a set of simultaneous equations.

Price and income expectations, and risk and uncertainty. Price and income expectations were represented by including current or lagged values of prices and income in input and asset adjustment equations. Simple averages of up to 5 years were sometimes used if more than one observed value was assumed relevant.

A major assumption was that an increase in commodity price variability specifically, and the elimination of farm programs generally, would increase the risk of investing in agriculture. Therefore the level of investment and current input expenditures for any given level of average price and income expectations would be reduced. The idea behind the assumption is that farmers will adjust to situations involving varying degrees of price and income uncertainty by sacrificing some potential profits to reduce the probability of financial disaster. Such adjustments depend on a farmer's psychological makeup and capital position, and they can take several forms:

- Adjusting the planned product mix to favor products with relatively low price and income variability
- Diversifying in a way that reduces net farm income variability
- Minimizing the probability that farm losses will lead to financial disaster by reducing the total amount of investment in the farm business which reduces the potential size of both profits and losses
- Increasing the firm's ability to survive loss experiences by increasing the share of total farm business investment held as financial reserves and operating with smaller amounts of borrowed capital.

(Elements of the first two adjustments may be involved when farmers choose to participate in specific voluntary price support-acreage diversion programs.) Because of the desire for financial reserves, an important interrelationship probably exists between annual investments, savings, family consumption, and risk and uncertainty. A realistic appraisal of the economic consequences of eliminating price stabilizing programs must consider this factor of farmers' risk aversion.[6]

Proxy indexes of the extent of risk and uncertainty were computed in the model as 5-year averages of the absolute annual percentage change in prices and in incomes. These indexes were included as explanatory variables in the behavioral equations for assets and inputs. Proxy indexes were computed for the following variables: (1) aggregate crop price index, (2) aggregate agricultural price index, (3) net income available for investment (net income plus depreciation allowances), and (4) the livestock-crop price ratio. Direct Government program payments to farmers (GP) were also used to explain resource adjustments; GP was assumed to represent a relatively certain source of net income for the coming year, once the annual program details had been announced by USDA.

Behavioral equations for the following variables contain one of the several risk and uncertainty proxy variables: repair and operation of machinery, fertilizer and lime, acres of cropland, repair and operation of buildings, miscellaneous inputs, buildings, land in farms, livestock number inventory, and farmland prices. Demand equations for machinery, labor, and onfarm crop inventories contain no risk proxies.

Crop input and productivity. Crop output is the product of three variables:

- Sum of four inputs (measured in 1957-59 dollar values) used primarily for crop production—fertilizer and lime, machinery inputs, acres of cropland for crops, and man-hours of crop labor
- Percentage of cropland harvested (exogenous)
- Output per unit of crop input

In specifying an output per unit of crop input equation,

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[6] This explanation follows Heady's (*11*, pp. 439-583). Support also appears in (*6, 9, 15*, and *16*). And see the recent quantitative analysis of farmer investment and consumption behavior reported in (*5*). also an empirical test of the hypothesis that farmers' cropping patterns and total outputs are influenced by a consideration of risk as well as expected income in (*18*).

crop productivity increases specifically, and farm technological advances generally, were assumed to have occurred along with, or partly because of, the greater use of nonfarm produced inputs relative to the traditional inputs of land and labor.

Farm technological change can be seen as the longrun result of specialization of labor and the associated highly successful innovative effort and research investment by persons in both the public and private sectors. The farm input and public sectors of the economy have become specialized producers of a continuous stream of new improved products and technologies that are used by farmers. Farmers, in turn, have become specialists in organizing and using these products so that inputs of land and human capital have become more productive. These changes have resulted mainly in response to economic incentives and they involve dynamic adjustments in the demand and supply of technology. Farmers have demanded improved inputs and techniques to maximize profits. And suppliers have developed the new products and techniques desired. Farm technological change depends on resource substitutions and capital outlays by farmers in response to:

- Changes in factor and product price relationships
- Cost and availability of new inputs and techniques
- Expected benefit from adoption of new inputs and methods
- Farmers' liquid and capital assets position
- Extent and importance to farmers of risk and uncertainty[7]

The output per unit of crop input index was estimated as a linear function of several variables:

- Percentage of cropland planted with hybrid seed
- Ratio of nonfarm produced fertilizer and machinery inputs to crop labor and cropland inputs
- Crop inputs subtotal
- Squared interaction term between the first two items in this list.

(Input and output measures used are value aggregates based on 1957-59 average prices.) The hybrid percentage was assumed to increase productivity because of the tremendous yield-increasing effect of shifts to hybrid corn and sorghum seed. Productivity was assumed to decline as total inputs increased, because, for example, greater land use would likely extend to less productive cropland. The ratio of nonfarm inputs to land plus labor was assumed to increase productivity. In the analysis of farm program impacts, this crop productivity equation significantly helped to explain longrun price trends and cycles. Because of the method used to specify the crop productivity equation, financial losses and business disasters simulated in the free market were ultimately reflected in a reduced level of nonfarm purchased inputs relative to land and labor. As a result, aggregate crop resource productivity went down and crop and livestock prices increased over time. Further, as prices rose in the model, additional cropland and other crop inputs were pulled into the system. But average crop input productivity was further decreased, which tended to dampen the supply response and retard the expected downward pressure on prices. This illustrates the advantage of endogenously simulating productivity in preference to using a simple extension of past trends.

Supply, demand, and prices. Total supplies of crops and livestock were set as identically equal to current production, plus beginning-of-year private stocks, and imports (for livestock, minus exports). The associated demand components include feed, seed, domestic human consumption, commercial exports, exogenous exports assisted by export subsidies or other specified Government programs, exogenous CCC net inventory changes, and end-of-year private stocks. Measures of "open-market," or "commercial," supply were defined as total supply minus Government market diversions (CCC net inventory changes plus Government-aided exports). Given the level of crop production, the supply and demand equations are used to simultaneously determine livestock production, livestock and crop prices, and the endogenous components of demand. Each such component is, directly or indirectly, a function of beginning-of-year private stocks, population, disposable personal income per capita, a nonfood price index, the various exogenous Government market diversion variables, exogenous crop exports and crop imports, crop production, and a time trend.

Alternative simulation sets, or runs, discussed below, were based on the use of alternative demand equations for domestic human consumption (because these could not be successfully estimated by usual regression analysis) and the use, in one simulation, of a synthesized equation for the foreign demand for crops.[8]

Aggregate prices, incomes, and other equations. Detailed results from preceding components of the model are used to compute an index of agricultural prices, various measures of income (including gross and net farm income and the rate of return in agriculture relative to the market interest rate), and several measures of price and income variability assumed to reflect the extent of risk and uncertainty. The quantity of hired farm labor and the hired farm wage rate are determined simultaneously. From these results, farm production expenses for labor and a residually computed family labor input are derived. Farm prices and the nonfarm

[7]These ideas are based on concepts in (*1, 10, 27,* and *6*). The quantitative procedure used was influenced by the work in (*17, 21,* and *32*).

[8]One set of domestic demand equations is based on the elasticity matrix of (*4*). Another set is derived using simple analysis of the relationship between income-deflated price and consumption, used in (*33*). Shortrun and longrun foreign demand elasticities for crops are based on (*28*).

wage rate are two of the explanatory variables determining the wage rate for hired labor. Farm land values and the number of land transfers per 1,000 farms are determined simultaneously. Farm prices, aggregate agricultural productivity, and nonfarm price levels are three of the variables used to explain land values.[9]

Output per unit of input for the total agricultural sector is derived from estimates of crop and livestock production and from the inputs previously estimated.

Other equations included in the model compute (1) the number of farms, based on an estimate of average farm size, (2) gross farm capital expenditures, (3) farm debt, and (4) total quantity and current value of assets.

Simulation Procedures and Alternatives

Results for three alternative simulation sets are discussed below.[10] Each set includes a simulation of a free market situation and the actual historical situation. These alternatives were developed because of the difficulty of estimating theoretically correct demand equations for domestic human consumption and crop exports by usual procedures. The three sets appear in table 3, and its footnotes describe the procedure and sources briefly.[11]

[9] Equation specifications were influenced by (*31*) for hired labor and (*14*) for land prices.

[10] The computer simulation procedure uses the Gauss-Seidel algorithm to obtain a solution of this nonlinear system by an iterative technique (*13*). Bob Hoffman and Hyman Weingarten, ERS, made programming revisions needed to facilitate use of the Gauss-Seidel procedure.

[11] Six additional simulation alternatives appear in (*19*, p. 232, table 19). These are based on arbitrary revisions in the resource adjustment equations made to allow for possible additional effects of increased risk and uncertainty in a free market.

Table 3.—Simulation alternatives

Demand assumption	Number for[a]	
	Historical simulation	Free-market simulation
Least inelastic demand assumption[b]	13	14
Moderately inelastic demand assumption[c]	18	19
Most inelastic demand assumption[d]	9	10

[a] These numbers identify the alternative simulations in the text, table, and charts of this article. [b] Domestic demand equations were based on domestic demand for human consumption elasticities shown in (*4*, pp. 64-66 and 46-51). Own elasticities for domestic consumption of crops and livestock are -0.274 and -0.259 respectively. Commercial crop exports were made endogenous by using foreign demand elasticities based on those reported in (*28*). The foreign demand elasticities are -1.0 in the short run and -6.0 in the long run. [c] Same domestic demand parameters discussed in previous footnote, but commercial crop exports were made exogenous and equal actual historical levels. [d] Crop exports were considered exogenous, as in footnote three, but domestic demand functions were derived by graphic analysis of the relationship between income deflated price and per capita consumption during the period. (See (*33*, pp. 11-18), for example). Here, own elasticities are -0.11 or -0.15 for livestock and -0.07 or -0.13 for crops.

EFFECTS OF ELIMINATING FARM COMMODITY PROGRAMS IN 1953

What would have happened in American agriculture had farm programs been eliminated in 1953? Some possible answers to this question are provided by the results in table 4 and figures 1-8. One measure of the

Table 4.—Effects on selected variables of eliminating farm programs in 1953, five-year averages, 1953-72[a]

Item	Percentage change from historical value			
	1953-57	1958-62	1963-67	1968-72
Crop supply to open market (CSPLY)[b]	8.4	2.6	-4.3	-9.5
Livestock supply to open market (LSPLY)[b]	3.8	4.8	3.4	-3.9
Price index for crops (PC)	-28.2	-22.6	-8.1	31.7
Price index for livestock (PL)	-19.5	-25.8	-18.5	25.2
Price index for agriculture (PA)	-23.2	-24.4	-14.9	27.7
Total net income (TNI)	-42.0	-37.7	-19.7	40.3
Total agricultural productivity index (TLB)	1.5	3.7	2.4	-5.1
Price index for land and buildings (PLD)	-4.6	-12.4	-16.8	-16.5
Gross farm capital expenditures (GCE)	-20.9	-54.3	-47.3	-12.7
Total production assets at end of year (ASSET)	-1.7	-7.0	-10.0	-10.0
Agricultural price variability index (SPA)	52.7	7.2	36.1	150.0

[a] Based on results of simulations 18 and 19, which use demand parameters derived from demand matrix in (*4*). Exports are assumed to be exogenous. [b] Supply includes production minus Government market diversions plus beginning-year private stocks plus net private imports for livestock and gross imports for crops.

PERCENTAGE CHANGE IN AGRICULTURAL PRICE INDEX: HISTORICAL TO FREE-MARKET LEVEL

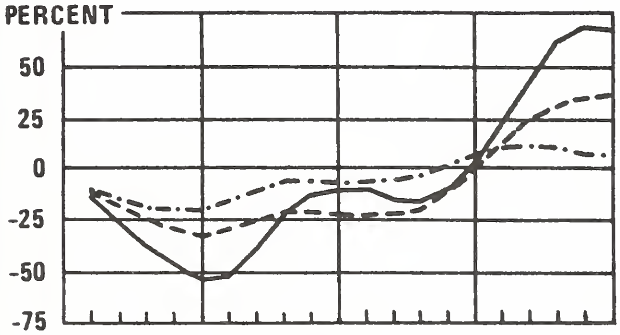

FIGURE 1

1952 '57 '62 '67 '72

SIMULATION	COMPARED WITH SIMULATION	INELASTIC DEMAND
—— 10	9	Most
– – 19	18	Moderately
–·– 14	13	Least

Note: See Table 3 for explanation of alternative simulations.

impact of farm programs on a variable is the difference between the simulated historical level and the simulated free-market level. Such differences are shown in figure 1 and table 4 as percentage changes from the historical to the free-market levels.

Alternative Impacts on Prices

The impacts of eliminating farm programs, on agricultural prices, for the three alternative simulation sets discussed in table 3, are shown in figure 1. The patterns of percentage impacts on prices for each demand alternative resemble one another to some extent. Each is initially negative and each grows over time until the largest negative impact occurs in 1957. Afterwards, the magnitude reduces gradually as the free-market price level becomes equal to and greater than the historical level by 1967. The largest positive impact occurs in 1969-71. However, the degree of impact differs importantly among the alternatives in most years, a behavior that highlights the important interrelationship between the assumed elasticity of demand and the estimated impacts of the farm programs.

Under all three demand alternatives, it is estimated that prices in the free market would have been lower than in actuality during 1953-65. By 1957, the reduction would have been 20 percent for the least inelastic demand assumption, 33 percent for the moderately inelastic demand assumption, and 54 percent for the

FERTILIZER AND LIME INPUTS: ACTUAL AND SIMULATED VALUES

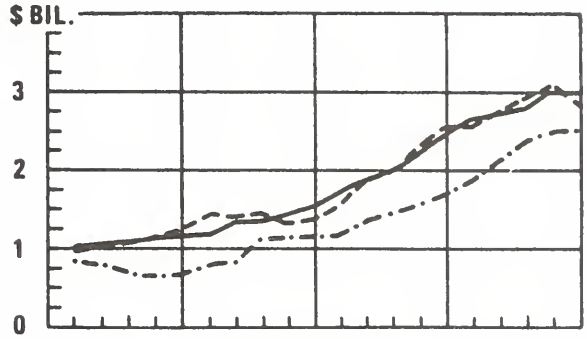

FIGURE 2

MACHINERY INPUTS: ACTUAL AND SIMULATED VALUES

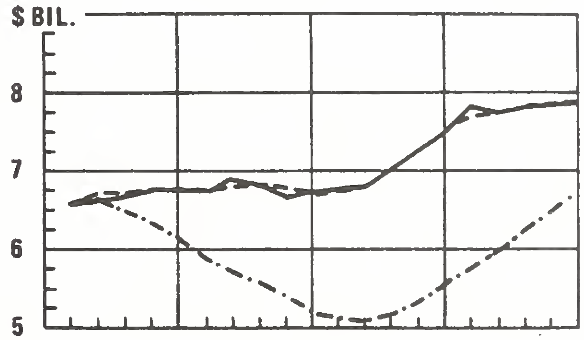

FIGURE 3

CROPLAND INPUT INDEX: ACTUAL AND SIMULATED VALUES

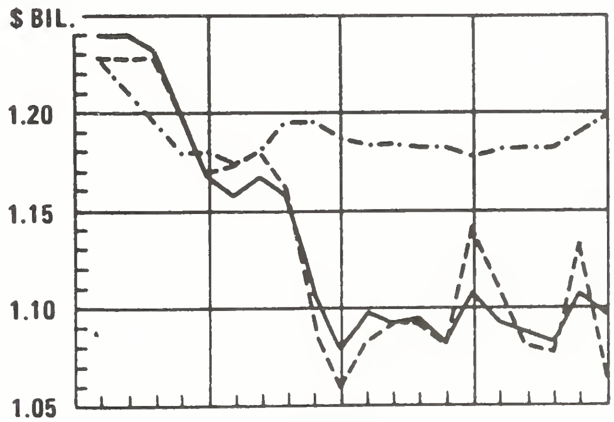

FIGURE 4

1952 '57 '62 '67 '72

—— ACTUAL
– – HISTORICAL*
–·– FREE-MARKET*

**Historical simulation 18 : free-market simulation 19.*

TOTAL AGRICULTURE PRODUCTIVITY INDEX: ACTUAL AND SIMULATED VALUES

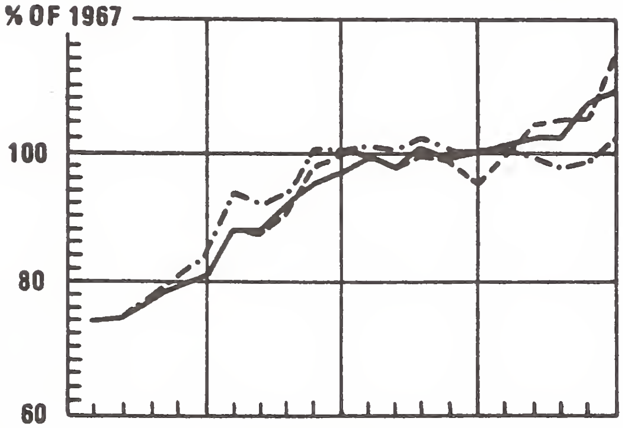

FIGURE 5

TOTAL NET INCOME INCLUDING NET RENT: ACTUAL AND SIMULATED VALUES

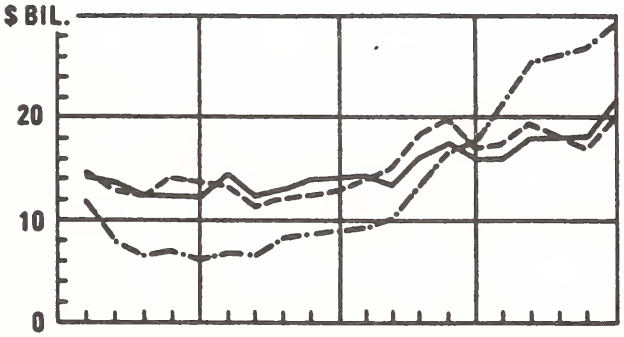

FIGURE 7

1952 '57 '62 '67 '72

—— ACTUAL
–– HISTORICAL*
–·– FREE-MARKET*

Historical simulation 18 : free-market simulation 19.

PRICE INDEX FOR AGRICULTURAL PRODUCTS: ACTUAL AND SIMULATED VALUES

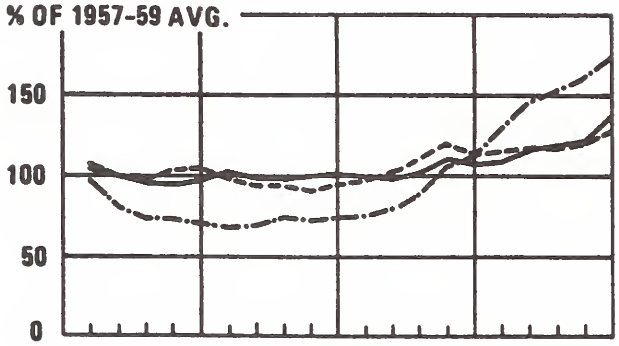

FIGURE 6

RELATIVE RATE OF RETURN TO FARM REAL ESTATE: ACTUAL AND SIMULATED VALUES

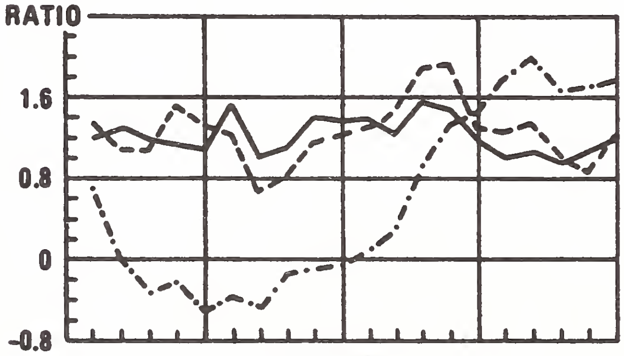

FIGURE 8

1952 '57 '62 '67 '72

—— ACTUAL
–– HISTORICAL*
–·– FREE-MARKET*

Historical simulation 18 : free-market simulation 19.

most inelastic demand assumption. In all three cases, prices would have begun to recover after 1957, but would not have returned to their actual historical levels until around 1967, 10 years after the 1957 low and 14 years after the programs had been eliminated. Prices would have continued to increase, relative to the historical situation, until they peaked during 1969-71. Eliminating farm programs in 1953 would have raised 1972 farm prices 6 percent under the least inelastic demand assumption, 35 percent under the moderately inelastic demand assumption, and 68 percent under the most inelastic demand alternative. Thus, farm programs kept farm prices higher than they otherwise would have been during 1953-65, but the cumulative effect was to keep them lower than otherwise during 1968-72.

This latter result differs importantly from those in other historical free-market studies. For example, Ray and Heady report that low free-market prices would have depressed income and increased supplies throughout their period of analysis—1932-67 (*25*, p. 40). In Tyner and Tweeten's study, prices are lower in the free-market simulation than in the historical simulation for all periods reported—1930-40, 1941-50, and 1951-60 (*30*, p. 78). In both studies, the supply response in agriculture is never enough for free-market farm prices to recover fully. One explanation is that the rate of technological advance was exogenous in the previous models while in this model, such change is endogenous.

Results For Moderately Inelastic Demand Alternative

Effects of eliminating farm programs in 1953 are also presented in table 4 and figures 2-8. These results are based on a comparison of historical simulation 18 and free-market simulation 19.[12] This set of results is not necessarily the "best," or "most correct." It was selected primarily because the results represent a kind of mid-range between the alternatives, as indicated in figure 1. Presenting only one set of results facilitates understanding the dramatic and interrelated effects that would have occurred in the absence of the programs.

Supplies and prices. Changes in the aggregate farm price level for the free-market situation, compared to actual history, resulted primarily from changes in crop supply and price. As one might reasonably expect, crop price adjustments also determined eventual livestock price adjustments. Over time, livestock producers adjust their inventory and production levels in response to changes in the livestock-crop price ratio. Crop price changes were determined mainly by changes in open market crop supplies tempered by simultaneous adjustments in feed use and private end-of-year inventory levels.

Actual crop prices were significantly affected by large Government market diversions equal to over 10 percent of actual production in 1953-55. With price-supporting activities eliminated in 1953, crop prices would have fallen sharply as stocks increased in the short run. In a free-market situation, private crop stocks would have been 17 percent higher than the historical level in 1955, and crop prices, 36 percent lower. Open market crop supplies would have continued to exceed historical supply levels throughout 1955-64, because crop production decreases would not have been large enough to offset the effect of elimination of Government market diversions. Actual diversions, substantial in this period, ranged from 7 to 16 percent of actual crop production, though 4-16 percent of the cropland was idled by existing programs. After 1964, however, crop production decreases in a free market would have become larger than actual Government market diversions under the program. Thus, free-market crop supplies would have fallen below historical levels in 1965; and, by 1972, they would have been down 11 percent. Crop prices would have been 36 percent higher in 1972 than they actually were in that year.

The relative decrease in crop production after 1964 would have dramatically affected farm prices throughout 1964-72 (fig. 6). As a result, 8 percent more crop related inputs would have been used by 1972, in the free market. *But crop productivity would have dropped 19 percent below the actual historical level, cutting crop production 13 percent.*

Farm income. Total net farm income, in the free market, would have averaged 42 percent below historical levels in 1953-57. Such income would have been 20 percent below the actual level in 1953. By 1957; income would have dropped $8 billion, to equal 55 percent of actual income that year. Further, though net farm income would have remained more than $3 billion lower through 1966, it would have finally risen to a level nearly $10 billion higher than historical levels in 1971 and 1972. Such income would have climbed 58 percent above the historical level in 1971, to average 40 percent higher during 1968-72 (fig. 7).

Figure 8 shows the impact of eliminating farm programs on the rate of return to farm real estate (relative to market interest rates). Residual returns to real estate in a free market would have been negative in 1954-62, making estimated losses comparable to those in the depression years, 1930-33. As with price and net income, the rate of return in a free market would have been higher than its historical level after 1967. However, the highest free-market rate of return ratio (RATO=2.0 in 1969) would not have been as high as that for the war-influenced period of 1942-48, when the ratio varied from 2.1 to 3.8.

Assets, investments, and land prices. Assets, value of capital expenditures, and land prices would all have been lower in a free market than historically for 1953-72 (table 4). Low prices and incomes and increased risk and uncertainty would have immediately and subsequently affected the amount of assets farmers would have been willing and able to buy. Gross farm capital expenditures would have declined dramatically. Reaching a level 59 percent below actual historical levels by 1960, they would not have returned to a point near actual levels until 1971 and 1972. Total productive assets in a free market would have averaged 10 percent below actual historical levels during 1963-72, and farm land prices would have averaged 17 percent below actual values.

Agricultural productivity. The agricultural productivity index would have been somewhat higher in a free market than it actually was from 1955 to 1968, reaching a high of 7 percent more in 1958. However, the longer term effect of eliminating farm programs would have been to reduce the productivity index to a level 11 percent below the historical level by 1972. In 1961, the index would have been 101 (1967 = 100), never to exceed 102 in subsequent years of the free-market simulation (fig. 5).

Crop productivity in a free market would have fallen below actual historical levels for all years after 1958, and would have been down 19 percent by 1972. Most of this 19-percent decrease would have been attributable to the decline in use of nonfarm inputs (such as fertilizer

[12] Historical simulation 18 can also be compared with the actual variable values plotted in figures 2-8. However, some equations have been adjusted to reproduce history more accurately than otherwise through use of regression error ratios. Such adjustment was considered desirable because the model is nonlinear. Thus, important disturbances in the equations could affect accuracy of the estimated program impacts.

and machinery) relative to cropland (figs. 2-4). The ratio of machinery and fertilizer to land and labor would have been 52 percent lower in the free market situation.[13] Also, the increased use of lower quality land would have reduced crop productivity; but an increase in the relative use of hybrid seed would have raised productivity. Decreased machinery inputs and increased use of cropland would have substantially raised labor inputs for 1957-72 in a free market.

Agricultural price variability. Absolute annual percentage changes in the agricultural price index would have averaged substantially above historical levels in a free-market situation. For the initial 5-year period, 1953-58, this index of variability would have averaged 53 percent higher. It would have continued above historical levels for all but 2 years. By 1968-72, the index would have averaged 150 percent higher.

Organization and structure. Several organizational and structural changes in agriculture would have occurred had farm programs been eliminated in 1953. Number of farms would have risen while the average size dropped. Land in farms relative to other assets would have increased, and cropland and labor would have been substituted for machinery and fertilizer inputs.

In the free market, the number of farms would have declined, but not as fast as it actually did. In historical simulation 18, number of farms declined at the average annual rate of 3.0 percent per year to a 1972 level of 2.7 million. In free-market simulation 19, the number of farms declined at the rate of 1.9 percent per year to 3.3 million in 1972. (The simulated number of farms was 4.7 million for 1953.) In 1972, there would have been 24 percent more farms than in actual history because the average size would have been 19 percent lower while total land in farms remained essentially unchanged. (Elimination of farm programs did affect land in farms prior to 1972.)

Average farm size in 1972 would have been much lower in a free market because agriculture would have been less mechanized, with more labor used per acre. A free market from 1953 on would have slowed the rate at which machinery and fertilizer and other nonfarm produced inputs were substituted for land and labor. Thus, farmers would have had less inducement to reorganize operations into larger sized units. In the historical simulation, the average size of farm increased at the average rate of 2.5 percent per year from 1953 to 1972. In the free market, this figure would have been 1.4 percent.

The share of total assets made up by land would have increased from 55 percent to 60 percent with a free market while shares for all other assets would have declined. Crop labor requirements would have risen from 7 to 15 percent of total current inputs. Cropland would have changed from 3 to 4 percent; livestock labor, from 4 to 5 percent. Other input shares would have declined.

Agricultural employment would have risen, with labor requirements 73 percent higher in 1972 than with farm programs. Most of the increased labor would have come from farm operators or their families. Family labor would have gone up 120 percent but hired labor inputs would have gained only 19 percent.

ASSESSMENT

The following summarizes results from simulations using demand relationships implying an aggregate domestic demand elasticity of around -.25 and assuming commercial crop exports are fixed at their actual historical levels in the free-market case (simulations 18 and 19). These results suggest that at least seven different impacts on the agricultural economy would have occurred had farm commodity programs of the Federal Government been eliminated in 1953:

- Farm prices would have dropped for several consecutive years until they averaged 33 percent below actual levels by 1957
- Aggregate farm prices would have been stable but low until after 1964, when they would have risen to a level averaging 35 percent above the actual figure in 1972
- Net farm income would have fallen 55 percent below the actual level by 1957 but it would have reached 58 percent above the actual level in 1971
- Residual returns to owners of farm real estate would have been negative in 1954-62
- Quantity of assets, value of capital expenditures, and farmland prices all would have been lower than actual levels throughout 1953-72, as a result of farmers' response to the initial and subsequently lower price and income experiences, lower expectations, and increased risk and uncertainty
- Land and labor inputs would have increased relative to other inputs, and the rate of decline in agricultural employment and number of farms during 1953-72 would have been reduced
- Crop resource productivity would have dropped under historical levels in all years after 1958, to be down 17 percent in 1972
- Agricultural productivity (crops and livestock combined) would have been 11 percent under actual levels in 1972.

Thus, farm programs had substantial and important effects on the developments in the agricultural sector during the period studied. In particular, the programs apparently worked to promote both long- and short-

[13] A net decrease in crop productivity in this free-market simulation results mostly from the effect of reduced machinery relative to cropland and labor. The effect of less use of machinery offsets a technically inappropriate positive effect of reduced fertilizer. The fertilizer sign comes from a negative partial derivative of productivity with respect to fertilizer of -0.1 obtained for the crop productivity equation.

term price and income stability. Apparently, the potential exists for continuous long-term food and fiber price cycling because of the nature of agricultural supply responses in a free-market situation. This cycling would occur, as the domestic and world economies grow, because domestic agricultural supply cannot grow at exactly the same rate as demand. The growth rate for supply is affected by complex interrelationships that exist between (1) adjustments in agricultural assets and inputs, in response to price and income experiences, and (2) adjustments in crop productivity and livestock production. During 1953-72, farm commodity programs were operated in a way that mitigated aggregate farm price and income cycling over extended periods.

This study suggests that farm programs supported farm prices and incomes at levels substantially higher than they would have been otherwise during 1953-65. Feed and other crop prices were supported by programs that idled productive land and diverted marketable supplies into Government storage or that subsidized domestic and foreign use. This resulted in reduced livestock production and consumption, and higher livestock prices. Farmers responded to these developments by mechanizing, fertilizing, increasing farm size on the average, and generally adopting technologies that reduced costs, boosted resource productivity, and expanded productive capacity. Elimination of farm programs in 1953 would have slowed the rate at which these advancements took place, or reversed the trend temporarily. The result: in recent years (1968-72), farm price levels would have been higher in a free market than in actuality.

Farm prices in the free-market simulation eventually recovered, and finally exceeded actual historical levels, because elimination of farm programs in 1953 put agriculture through the "longrun wringer."[14] With free-market prices 10 to 30 percent below actual levels throughout 1953-66, and a negative rate of return to real estate for a number of years, gross capital expenditures and current input expenditures were greatly reduced, and agricultural productivity and output growth retarded. The eventual result in the free-market simulation was that farm prices increased dramatically as aggregate demand grew faster than aggregate supply. Farm commodity programs held farm prices and incomes *higher* than would have been true otherwise for 1953-65, which apparently provided the economic incentives to growth in output sufficient to hold farm prices *lower* than they otherwise would have been for 1968-72.

These results suggest that the national agricultural plant can and does respond to changes in economic incentives, given sufficient time. But because substantial time is required to change agricultural capacity, long periods of substantial disequilibrium and disruption can result in a free market. Without farm commodity programs, consumers would have enjoyed low farm product prices through 1964. Farmers, at the same time, would have suffered their worst financial crisis since the Depression. But these low prices would have been replaced by high farm prices, following a long period of rapid farm price increases after 1964. At the same time, farm incomes would have been improved greatly.

[14] Cochrane discussed how the "longrun wringer" could "correct" the surplus condition in agriculture in (*1*, pp. 134-136).

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Effects of Relative Price Changes on U.S. Food Sectors, 1967-78

By Gerald Schluter and Gene K. Lee*

Abstract

For a half-century the parity ratio has served as the most commonly used measure of the effects of relative price changes on the farm economy. The authors present a consistent economic model which measures the price-related income effects of relative price changes in selected sectors of the U.S. economy during the 1967-78 period and use this model to analyse selected sectors within the food system. Their model improves and expands upon the parity ratio. It provides more detailed information within the farm sector, and it provides conceptually consistent measures of the effects of relative price changes in the nonfarm sectors of the food system.

Keywords

Relative price changes, Parity ratio, Input-output analysis, Food system, Farm sector, Inflation

The first step, forming a clear idea of the ultimate use of the result, is most important, since it affords the clue to guide the compiler through the labyrinth of subsequent choices. It is, however, the step most frequently omitted.
Wesley Mitchell, 1915

Introduction

Mr. Mitchell was referring to constructing a price index, but his advice is as true today as it was 65 years ago (*5*).[1] Equally true, we suggest, is a corollary for choosing a price series. The first step, determining the purpose for which the price index is constructed, is most important, since it affords the clue to guide the user through the labyrinth of subsequent inappropriate uses. A classic example of the failure to follow this corollary is the parity ratio.

The parity ratio has survived 50 years of criticism, and it will likely continue to be used because it is timely (some price data are only about 2 weeks old when published), readily available, and easily understood. In this article, we briefly review its suitability as an indicator of the effect of relative price changes on agriculture and compare it with two alternative price series. Then we present a consistent economic model which measures the effects of relative price changes on selected farm, food-processing, and energy-related sectors of the U.S. economy during the 1967-78 period, which, we propose, provides a better indicator of the effects of relative price changes in the food and agricultural sectors.

At the core of most attempts to support farm income has been the desire to maintain the purchasing power of farmers. Often this effort has taken the route of maintaining relative prices, since makers of agricultural policies have recognized that high or low prices for farm products are not in themselves of major importance. Of far greater importance is the purchasing power of farm products in terms of the items farmers must buy for living and for their businesses. In response to these needs, the U.S. Department of Agriculture (USDA) developed, and first published in 1928, the parity index. The parity index, or the Index of Prices Paid by Farmers for Commodities and Services, Interest, Taxes, and Wage Rates, is expressed on the 1910-14 = 100 base. This parity index was used in conjunction with the Index of Prices Received by Farmers to yield a measure of farmers' purchasing power. One obtains this measure, the parity ratio, by dividing the Index of Prices Received by the parity index. The concept of a parity ratio has been critized almost from its start (*3*). Many criticisms have resulted from improper use by data users rather than from problems with the parity ratio series itself. The parity ratio is a price comparison. It is not a measure of cost of production, standard of living, or income parity (*9*). Nor is it more than one of many indicators of well-being in the farm sector. Many of the criticisms of the parity ratio have resulted from attempts—contrary to Mitchell's advice—to make it serve roles for which it was never intended.

Because the Prices Received Index reflects only farm commodities and the parity index includes farm-household consumption items as well as production expenditures, the

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[1] Italicized numbers in parentheses refer to items in the references at the end of this article.

parity ratio most closely mirrors the situation of a farm-operator household in which the household's income comes entirely from farm production. Relatively few farm households today depend solely, or even primarily, on income from farm sources. Moreover, using the ratio as a broader indicator to measure relative price changes for agriculture as an economic sector presents some conceptual problems. The Prices Paid Index is more inclusive than the Prices Received Index. In addition to current production items, the parity index includes consumption items and capital expenditure items, as well as inflation premiums in interest rates and possibly in capital inputs. Heady (*1*, p. 142) points out the parity ratio is faulty in a formal supply sense because the parity index does not include the implicit cost of resources already committed and specialized to agriculture. A sector measure of relative price changes would include only the prices of current output and current inputs. Considering only current output and input prices has the additional advantage of avoiding the measurement problems which Heady enumerates and the problems of quality adjustment in capital goods prices and inflation premiums in interest rates.

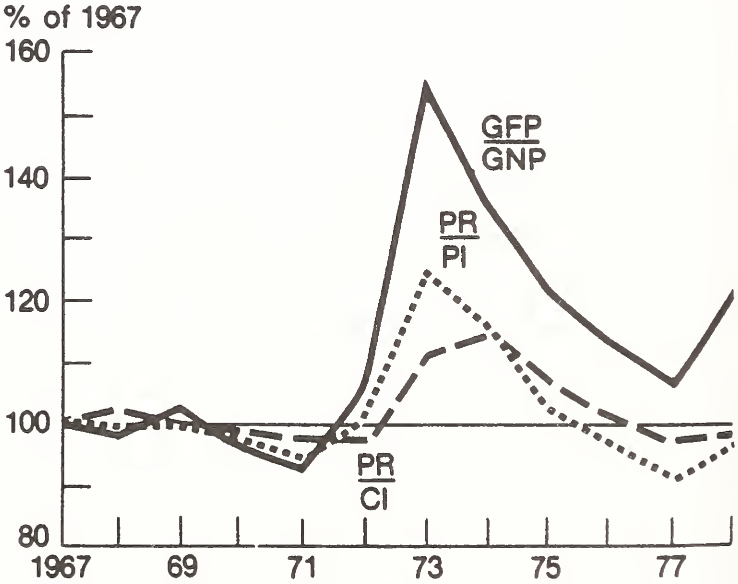
A price series which meets this criterion, measuring only current economic activity in the farm sector, is the implicit price deflator for gross national product (GNP) originating in agriculture, or the gross farm product (GFP). The implicit GFP deflator includes on the output side not only prices of commodities sold but also changes in farm-related income, the value of inventory changes, and selected imputed items, and on the input side, purchased current goods and services and rents paid. Comparing the implicit GFP deflator to the implicit GNP deflator provides a reference as to how price changes affect the farm sector relative to the general economy. Applying this approach, we present a consistent economic model[2] in which the combined price effects on 16 farm commodity sectors nearly add to the implicit GFP deflator and in which the price effects on all the model's sectors nearly add to the implicit GNP deflator.

Figure 1 presents three alternative measures of the effects of relative price changes on the farm sector. The "parity ratio" line (PR/PI) presents the traditional—albeit inappropriate for our purpose—measure of the farm-sector relative price. Technically, the parity ratio is defined on a 1910-14 base; however, we use the same price series with a 1967 base. The GFP/GNP line is the standard just discussed and also illustrates the type of standard used in applying the model. The PR/CI line presents an unpublished price series constructed to make the parity ratio approach a more appropriate concept for our purposes. As in the "parity ratio" line, the numerator of the ratio is the Prices Received Index (1967 = 100). The denominator, however, is the Index of Prices Paid by Farmers for Production Items after removing capital items (autos, trucks, tractors, machinery, and building and fencing materials). The remaining index and resulting ratio reflect current production activity.

The three measures follow similar patterns. All three measures agree that for 1970 and 1971 farm purchasing power decreased and that for 1973-75 farm purchasing power increased. The average of the ratios for 1967-78 for all three measures exceeds 100, suggesting that even though the two "parity ratio" related measures ended the period below 100, farm purchasing power increased relative to the general economy over the entire period.

Figure 1

Alternative Price Series Measuring Relative Price Effects on Farming



[2]In a consistent economic model the output of each industry is consistent with the demands, both final and from other industries, for its products. A consistent economic model insures that estimates for individual sectors and industries will add up to a total estimate (for example, GNP).

Many of the criticisms of the parity ratio have resulted from attempts—contrary to Mitchell's advice—to make it serve roles for which it was never intended.

Purchasing power as reflected here is purchasing power due to relative price changes but not to any change in the volume of economic activity. Our measure of farm-sector purchasing power (implicit GFP deflator) is also conceptually consistent with the general measure of the dollar purchasing power in the general economy (the implicit GNP deflator). Here we present a consistent economic model which provides similar estimates of the effects of relative price changes during the 1967-78 period on selected farm, food-processing, and energy-related sectors of the U.S. economy. We demonstrate that our individual farm sector estimates nearly add to the GFP implicit price deflator and together with nonfarm sectors nearly add to the implicit GNP deflator.

Method

The economic model used for our analysis is adapted from Lee and Schluter (*4*). We used an input-output framework to measure the income effects of a change in relative prices on each sector of the model.[3] Outputs in the model are held constant; so are the values for imports and the inter-industry flows. The constants function as weights for price changes in the same way that base-period quantities function as weights in a Laspeyres price index, such as the parity index. This similarity to a Laspeyres price index provides a check on the model's performance and shows the vulnerability of the food sector to the relative price changes which have accompanied recent inflation. We used a simplified form of the Lee-Schluter model:

$$r = [e\, D_p (I-A) - m]\, D_0$$

where:

r = $1 \times n$ vector of values added, v_i
e = $1 \times n$ vector of 1's
D_p = $n \times n$ diagonal matrix of price changes relative to a year; p_{it}/p_{i0}
I = $n \times n$ identity matrix
A = $n \times n$ technical coefficients matrix, a_{ij}
m = $1 \times n$ vector of import coefficients, m_i
D_0 = $n \times n$ diagonal matrix of base period sector output, O_i[4]

[3]The definition of income in input-output is synonymous with the value created. Thus, residual income includes proprietors' income, rental income, corporate profits, net interest, business transfer payments, indirect business taxes, and capital consumption allowances.

[4]Conventional I/O notation uses X to refer to the value of output. We use P_iO to distinguish between the value of output (X_i or P_iO_i) and real output (O_i).

Thus, the value-added series for a particular industry is the 1967 value added to cover profits, rents, interest, taxes, and wages adjusted for changes in that industry's output price and its intermediate input prices. Import prices are held constant at base-period levels.

For our analysis, we used a 42-sector aggregated version of the 1967 national I/O table (*13*) for the import and the domestic input-output coefficients and, thus, for the base-year income, final demand, and output estimates. Table 1 presents these 42 sectors with the price series selected to represent the annual changes in price level of each sector.

Evaluation

Table 2 summarizes the model's performance. Column 1 gives the model's estimate of the implicit price deflator for farm value added; column 2 gives the U.S. Department of Commerce implicit price deflator for GFP; and column 3 gives the ratio of the two series. As column 3 shows, except for 1974, 1977, and 1978, all the model's estimation errors were 2.8 percent or less. An analysis of the pattern of estimation errors suggests a subtle difference in weights between those implicit in the I/O matrix and those implicit in the price series used by Commerce. The I/O model apparently assigns more weight to the crop sectors. Thus, when livestock prices increase relative to crop prices, our model underestimates the Commerce series. As many crop prices were rising in 1974 while many livestock prices were falling, our model overestimated the implicit price deflator for that year.

Columns 4 through 6 compare total GNP for the 1968-78 period.[5] Our model estimated better for the whole economy than for an individual sector (farm, in this case), with an average error of 1.1 percent and with only one estimation error above 2.5 percent. The model consistently underestimated GNP during the period from 1967 to 1975.

[5]A comparison of columns 2 and 5 shows another difficulty in determining the role of agriculture in general inflation. The volatility of agricultural prices leads to volatile estimates of their role in general inflation. The 1978 implicit GFP deflator of 232.6 represents an 8-percent annual rate of increase, well above the 6.1-percent rate in the GNP deflator. Yet the GFP deflator decreased in 5 of the 11 years; almost all the increase came in 1969, 1972, 1973, and 1978. Thus, while the GNP deflator increased each year, in only 4 of the 11 years, did the change in the GFP deflator rate exceed the change in the GNP deflator-rate. Over the 11-year period, the farm-sector price deflator grew faster than the national deflator rate. Yet, in 6 of those 11 years, the rate of increase in the farm sector was less than one-third that for general price levels.

Table 1—Sectoring plan and associated price series[1]

Sector number	Sector description	Price series[2]
1	Dairy farm products	Farm income accounts, season average
2	Poultry and eggs	do.
3	Meat animals	do.
4	Miscellaneous livestock	do.
5	Cotton	do.
6	Food grains	do.
7	Feed grains	do.
8	Grass seed	do.
9	Tobacco	do.
10	Fruits	Prices received
11	Tree nuts	Farm income accounts, season average
12	Vegetables	Prices received
13	Sugar crops	Farm income accounts, season average
14	Miscellaneous crops	do.
15	Oil-bearing crops	do.
16	Farm-grown forest and nursery products	Prices received
17	Meat products	Producers Price Index
18	Dairy plants	do.
19	Canning, freezing, and dehydrating	do.
20	Feed and flour milling	do.
21	Sugar	do.
22	Fats and oils mills	do.
23	Confectioners and bakeries	do.
24	Beverages and flavorings	do.
25	Fertilizers	do.
26	Petroleum refining and related products	do.
27	Miscellaneous food processing	do.
28	Tobacco manufacturing	do.
29	Textiles, apparel, and fabrics	do.
30	Leather and leather products	do.
31	Crude petroleum	do.
32	Coal mining	do.
33	Forestry, fishing, and other mining	do.
34	Other manufacturing	do.
35	Transportation and warehousing	WEFA
36	Wholesale and retail trade	do.
37	Other noncommodities	do.
38	Electric utilities	Producers Price Index
39	Gas	do.
40	Real estate	WEFA
41	Special industries	Assumed unity
42	Imports	WEFA

[1] Detail greater than was required for the food-system analysis, reflected in the sectoring plan, is due to the inclusion of alternative-sector, analytical capabilities for the model.
[2] Farm income accounts = season average price used in cash receipt estimates; Prices received = Index of Prices Received by Farmers; Producers Price Index = U.S. Bureau of Labor Statistics' Producers Price Index; WEFA = (*15*). The specific variables from these series for each sector are available from the senior author upon request.

Columns 7 through 9 provide a third measure of the performance of our model. Column 8 gives the actual ratio of the GFP deflator over the GNP deflator as graphed in figure 1. Column 7 gives the ratio of our estimates of these statistics, and column 9 gives the ratio of our estimates of the ratio to the actual ratio. Our model predicted the actual ratio within 2 percent for 7 of the 11 years. Although fairly sizable errors occur in 1973, 1974, 1977, and 1978, only in 1977 does the model incorrectly predict the movement of the GFP deflator relative to the GNP deflator.

These implicit value-added price series are useful economic data not otherwise available. They show the analysts how the sector has fared in the maze of interacting price relationships that characterize a dynamic economy.

The relative movements provide useful information. One must avoid giving too much weight to the levels as the level of output and input substitution have been fixed at base-year levels. Thus, the income level estimated by the model may differ from the actual income level of the sectors. A

These implicit value-added price series are useful economic data not otherwise available. They show the analysts how the sector has fared in the maze of interacting private relationships that characterize a dynamic economy.

Table 2—Comparison of model estimates with gross farm product (GFP) and gross national product (GNP) deflators, 1968-78

Year	GFP deflator			GNP deflator			GFP deflator/GNP deflator		
	Estimate	Actual[1]	Estimate/ actual	Estimate	Actual[1]	Estimate/ actual	Estimate	Actual	Estimate/ actual
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1968	103.4	102.8	1.006	103.9	104.5	0.994	0.9952	0.9837	1.0117
1969	109.5	112.4	.974	109.0	109.7	.994	1.0046	1.0246	.9805
1970	109.3	111.4	.981	113.4	115.6	.981	.9638	.9637	1.0001
1971	109.7	112.7	.973	118.6	121.5	.976	.9250	.9276	.9972
1972	131.1	133.7	.981	122.5	126.6	.968	1.0702	1.0561	1.0134
1973	212.2	207.1	1.025	130.6	133.9	.975	1.6248	1.5467	1.0505
1974	218.9	199.5	1.097	145.9	146.8	.994	1.5003	1.3590	1.1040
1975	193.5	195.2	.991	160.8	160.9	.999	1.2034	1.2132	.9919
1976	192.4	191.6	1.004	169.5	169.2	1.002	1.1351	1.1324	1.0024
1977	179.0	191.4	.935	180.3	179.3	1.006	.9928	1.0675	.9300
1978	221.1	232.6	.951	193.8	192.4	1.007	1.1409	1.2089	.9437

[1]Source: (*14*).

final caveat: it is difficult to establish a base year when all sectors of the economy were "normal," and determining the base year by the scheduling of an economic census may increase the likelihood of choosing a year when a number of sectors were atypical. In our model, these atypical situations have become the norm by which other years are measured. One must remember this difficulty when making intersectoral comparisons.

Relative estimates of the effect of price changes are derived from an economic model which describes the interrelatedness of the U.S. economy. The model is consistent. The model can be validated, and we did validate it, by aggregating individual sector estimates for comparison with published aggregates. However, this is not the chief value of our method. More important, this series is the first systematic, internally consistent set of estimates of the relative vulnerability of parts of the food system to recent relative price changes. These estimates for individual sectors include the price-related income effects on all participants, farm operators, workers, interest recipients, and others who commit factors (labor, capital, land, and others) to the individual sectors.

Model Limitations

The model uses the level and mix of real output in 1967. Thus, the model does not incorporate any changes in income earned by a sector due to changes in level of output or the mix of final demand. It only accounts for changes in income due to changes in relative prices.

Similarly, the weight given each price in calculating this income effect is its weight in the 1967 industry cost function (direct requirements column). Thus, input substitutions due to price changes are ignored, as are input coefficient changes due to changes in production technique. Although these assumptions could lead to potentially serious biases, this problem is common to the use of fixed-weight indexes. Although we do not overlook this potential bias in our model, we accept it as an occupational hazard. Due to the fixed weights, the results can be interpreted as the change in the value added, with all input (primary and intermediate) and output quantities held fixed because of price changes occurring during the 1967-78 period.

Another potential source of error in the model occurs when the series chosen to represent the price effects of a specific sector fails to fulfill this function. The price series chosen may not properly reflect the price changes in that sector, or the collection of price data may differ from commodity marketing patterns.

Finally, these income estimates should not be confused with sector or industry profits, although profits are a component of the income estimates. Rather, our income estimates include wages, interest, depreciation allowances, rents, and indirect business taxes as well as profit-type income. Thus, one dollar of increase in income represents one more dollar of income available for distribution to these factor suppliers.

Results

We discuss our results by groups of sectors. The crop sectors are divided into those more directly influenced by world markets and those more reliant on domestic markets. The food processing sectors are divided into those processing farm livestock products, those processing farm crop products, and those further processing food products. Groups also discussed are farm livestock and energy-related sectors.

Figures 2 through 6 depict graphically our results as percentage variations from the income level in 1967. Thus, a value of zero represents no change; a value of one represents a doubling of base-year income; and a negative number represents an income loss. The implicit GNP deflator is included in each figure to provide a comparison with the overall rate of inflation.

World Market Crop Sectors

Figure 2 presents the estimated income levels of the export-oriented crop sectors relative to the 1967 levels. During the 1968-70 period, relative prices moved to the economic detriment of all these sectors, and their incomes fell below 1967 levels. The oil crops sector first crossed the baseline in 1971 and was 33 percent above it by 1972. Then, with the export boom, the domestic terms of trade shifted dramatically in favor of all four of these crop sectors. The most dramatic shift occurred in the food-grain sector. All four sectors peaked in 1974; income levels fell in 1975 and continued to fall in 1976, except for cotton (for which price and income recovered to above 1974 levels) and for oil crops (which rose slightly from its 1975 income level). In 1977, the oil crops sector continued to rise, but the others dropped. Cotton and food grains rose in 1978; but oil crops stabilized, and feed crops continued to fall.

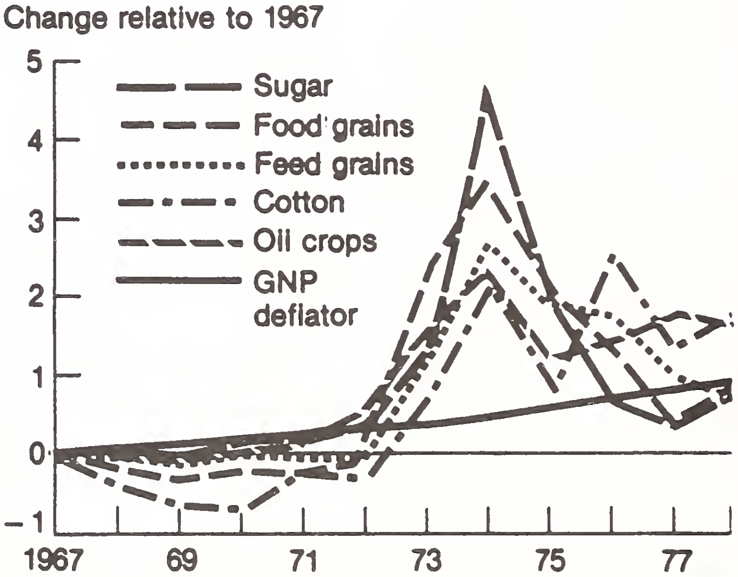
Because we import a significant share of our domestic sugar, the sugar crop sector is subject to different forces than are other crops. With the expiration of the Sugar Act and a strong world demand for sugar, the income of the sector soared in 1974, dropped (but remained strong) in 1975, and fell again to near 1967-73 trend-line levels in 1976, 1977, and 1978 (fig. 2).

Domestic Crops

In contrast to the world-market crop sectors, the income of the domestic crop sectors (vegetables, fruits, and tree nuts) did not shift dramatically due to relative price movements.

Figure 2

Change in Income Due to Price Changes, World Market Crop Sectors



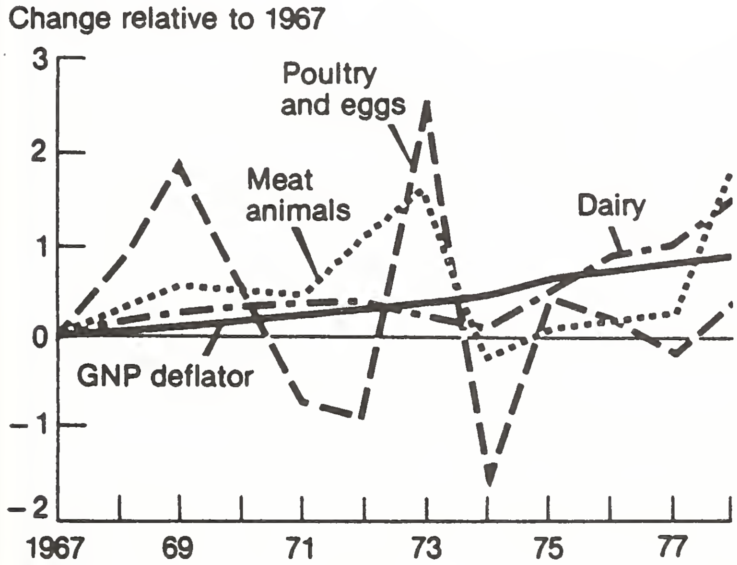
In fact, except for 1968 and 1973, the value-added indexes of these sectors were consistently below the overall standard (the GNP deflator) until 1978, when fruits and tree nuts finished the 1967-78 period above the standard.

Livestock Sectors

The livestock sectors, especially poultry and eggs, were more vulnerable to price changes (fig. 3). Some of the variability in poultry and egg income was due to a relatively low income level in the base year, which accentuated the degree of income fluctuations as relative prices changed. Furthermore, the output price for this sector tends to vary more than the input prices, which introduces income variability. Thus, in 1968 and 1969, poultry and egg prices were 7 and 21 percent, respectively, above 1967 levels, leading to income 80 and 180 percent, respectively, above the base period. Conversely, in 1971 and 1972, when price levels were only 3 and 5 percent, respectively, above 1967, income levels were 73 and 89, percent, respectively, below 1967. A subsequent price rise in 1973, to 79 percent above 1967 levels, sent incomes soaring, to 250 percent above base level. When the

Figure 3

Change in Income Due to Price Changes, Livestock Sectors



poultry and egg price index dropped 17 index points in 1974, while the feed crop price index increased 72 index points and the grain mills (manufactured feeds) PPI increased 22 index points, the poultry and egg sector income plunged to negative levels. Subsequent strength in poultry and egg prices, together with weaker feed prices, allowed 1975 and 1976 estimated income levels to recover to levels 38 and 15 percent, respectively, above base period before falling again below base level in 1977 and recovering to 28 percent above base level in 1978.

The meat animal sector was less volatile than the poultry and egg sector because of a larger base-year income and more stable output prices. The sharp drop in the meat animal index in 1974 does not appear in other economic indicators, such as the Index of Prices Received by Farmers for Meat Animals. Figure 4 dramatically illustrates the superiority of the proposed index of relative income over ordinary price indexes. The relative income index allows explicitly for higher feed costs, whereas the Index of Prices Received by Farmers for Meat Animals does not. The meat animal sector experienced 2 strong years (1972-73) before price weaknesses and higher feed costs took their toll. From 1974 to 1977, the Index of Prices Received by Farmers for Meat Animals was fairly constant (165, 169, 170, and 168); thus, any increase in strength of sector income resulted from slightly lower input prices. Price strength in 1978 improved the income position of this sector to 175 percent above base level. Relying solely on the Index of Prices Received by Farmers for Meat Animals would have been misleading because of changes in input prices.

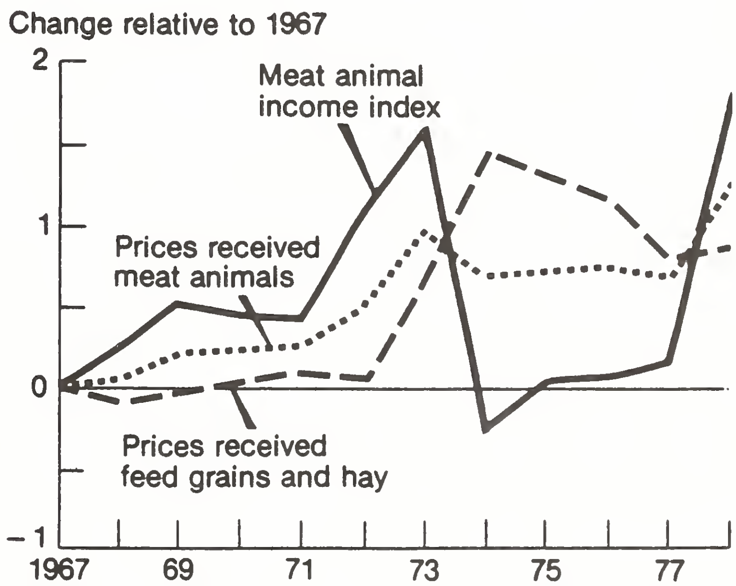
The income pattern in the dairy sector (fig. 3) was rather stable for most of this period, with exceptional strength since 1976. From 1975 to 1978, the dairy-product price index rose 20 percent above 1975 levels, whereas the feed-crop price index fell 20 percent. As a result, sector income rose from 39 percent above base level in 1975 to 143 percent above base level in 1978.

Livestock Processing

The stable price and income pattern that we observed for the farm dairy sector is even more pronounced for the manufactured dairy products sector (fig. 5). From 1967 through 1975, the estimated income levels stayed within 10 percent

Figure 4

A Relative Income Index Contrasted With Comparable Price Indexes



of base year levels; not until 1976 did they exceed 10 percent. Nonetheless, the sector was losing ground relative to the implicit GNP price deflator. Apparently, this sector is able to pass on increases in the farm price of milk, but the demand for milk prevents larger increases.

The meat- and poultry-processing sector faces a different demand situation (fig. 5). As the farm price of meat animals and poultry rose in 1971-73, the meat- and poultry-processing sector apparently did not pass on higher raw product costs, and income levels fell almost 40 percent below base level. After 1973, the PPI for processed meats showed more resilience than farm prices, and the income position of this sector rose during the 1974-75 period; it later dropped to more modest levels.

Farm Crop Processing

Figure 6 shows the variety of income responses of food manufacturing sectors to explicit changes in prices of their respective farm raw materials. The feed and flour-milling sector exhibits tendencies similar to those in the meat-processing sector. Millers apparently did not pass on all costs of higher priced grain inputs during 1974 and 1975, and incomes dropped to near 1967 levels. But their 1976 and 1977 output prices rose 4 and 2 index points, respectively, over 1975 levels, while the food-grains price index fell 37 and 80 index points, respectively, from 1975 levels, resulting in income jumps of 43 and 54 percent, respectively, above base levels.

Figure 6

Changes in Income Due to Price Changes, Crude Crop Processing Sectors

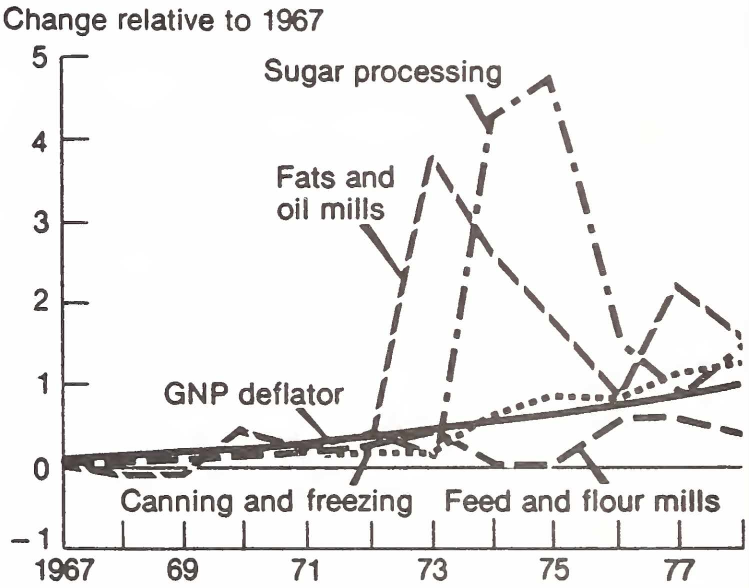
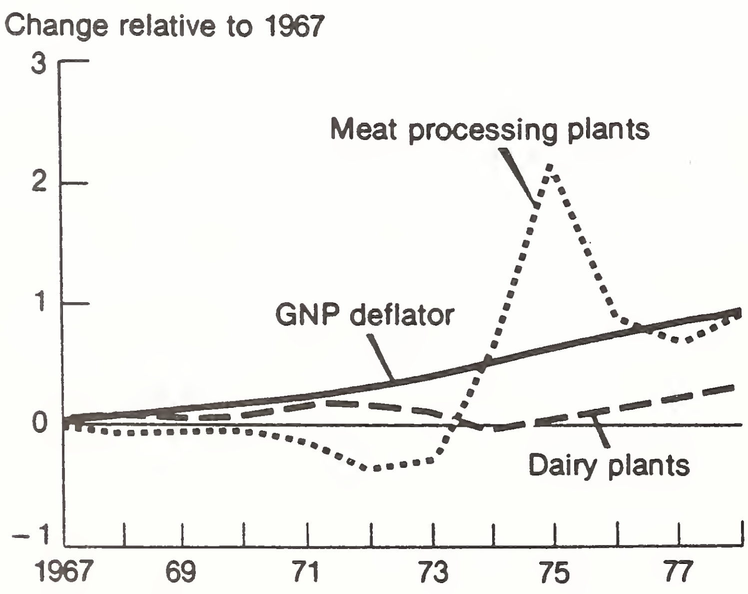


Figure 5

Changes in Income Due to Price Changes, Livestock Product Processing



The fats and oils refining sector exhibited a different pattern. Its income pattern roughly parallels that of the oil crop sector, which suggests that the sector is able to pass through increased raw material costs and a proportional margin to its customers, but the nature of the sector's supply and demand conditions does not allow it to maintain its output price when associated farm prices decline. An exception to this parallel pattern occurred in 1976 when the refining sector's income fell, while oil crops income rose slightly.

The sugar refining sector benefitted from large increases in world sugar prices in 1974, and it increased its income position slightly in 1975 when the sugar crop sector declined. By

Our model is useful because it shows which sectors of the food system have gained from the relative price changes accompanying the recent inflation and which sectors have lost.

1978, however, incomes in this sector had returned to a level about 145 percent above base level.

After a fairly stable, but increasing, income level during the 1967-73 period, the canning, freezing, and dehydrating sector income grew considerably during 1974 and 1975, weakened somewhat in 1976, and ended the period 111 percent above base level.

Highly Processed Foods

The three highly processed food sectors were relatively stable, exhibiting no abrupt annual fluctuations. For example, the confectioners and bakeries sector retained its 1967 income level throughout 1968; its income increased to 30 percent over base in 1969, then reached a 40-50 percent plateau where it stayed through 1973. After 1973, the sector income rose steadily for 2 years to a new plateau of 85-90 percent above base level in spite of high sugar prices. By 1978, its price-related income position was 103 percent above base level.

The income level of the flavoring and beverages sector was nearly constant from 1969 through 1973, rose sharply from 1974 to 1977, then dipped in 1978.

The miscellaneous food processing sector did not show strong income growth during the 1968-78 period.

Energy-Related Sectors

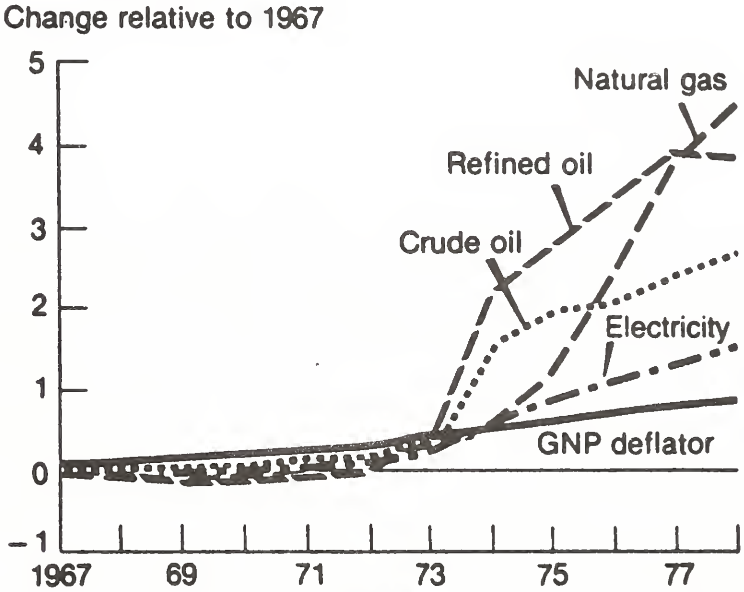
The plot of income due to relative price changes for energy-related sectors illustrates a pattern characteristic of the U.S. energy price situation. From 1967 to 1973, the real price of energy declined annually; after 1973, it rose to allocate tight supplies of oil and gas. The plot for the energy-related sectors (fig. 7) contrasts with plots for the farm sectors. Whereas the farm sectors did not retain any income peaks resulting from relative price shifts in their favor brought about by supply or demand shocks, the energy-related sectors have been able to retain income levels resulting from relative price changes.

Conclusion

Our model is useful because it shows which sectors of the food system have gained from the relative price changes accompanying the recent inflation and which sectors have lost.

Figure 7

Changes in Income Due to Price Changes, Energy Sectors



We have proposed, as a rough measure of the relative position of a sector with respect to inflation, its sector value-added price deflator relative to the GNP implicit price deflator. This comparison is available from the sector's value-added deflator lines and the GNP implicit price deflator in each figure.

Since 1973, except for feed crops in 1978 and food grains in 1977 and 1978, all export-oriented crops have exceeded the national norm (the implicit GNP deflator) and have benefitted from the relative price changes accompanying inflation by an amount likely to offset their less favorable position from 1967 to 1973.

Sugar has benefitted from the recent relative price changes accompanying inflation. Domestic-oriented crops have been relative losers. On balance, fruits, tree nuts, and vegetables have been relative losers. Since 1973, all the livestock sectors, except dairy in 1976 and 1977 and dairy and meat animals in 1978, have been below the national norm. From 1967 to 1973, the meat animal sector was a relative gainer, as were dairy in 1967-72 and poultry and eggs in 1967-70. The livestock sectors gained in the years when the general farm price

levels were rising slowly, but lost during the big farm price surge. Among livestock-product processing firms, the dairy food manufacturing sector has consistently been below the national trend. Meat and poultry processing was not only below the national trend but also below the base year during the 1967-73 period; it caught up with the national trend in 1974, was above it in 1975-1976, and below it in 1977-78.

Among the sectors processing crude farm crops, fats and oils mills have exceeded the national trend since 1970. Sugar refiners reached trend levels in 1970, and canning, freezing, and dehydrating reached trend levels in 1974. On balance, fats and oils mills and sugar refiners were gainers; grain mills were losers, and canners were unchanged.

Among the more highly refined food-processing sectors, confectioners and bakeries benefitted from relative price changes accompanying inflation, as have beverages and flavorings in recent years. The miscellaneous food processing sector has not benefitted.

Implications

Our results, which illustrate sector vulnerabilities to the relative price changes characterizing an economy adjusting to inflation, are not without lessons.

We have seen that if one uses the standard of the GFP implicit price deflator relative to the GNP price deflator, the farm sector has benefitted from relative price changes since 1972 (fig. 1). Previous studies of the effects of relative price changes on agriculture during the inflationary periods have not gone beyond the farm sector. Tweeten and Quance (*11*) found that farmers were disadvantaged by input price inflation. They concluded that a 10-percent increase in the Prices Paid by Farmers Index reduces nominal net farm income by 4 percent in the short run and by 2 percent in the long run. Tweeten and Griffin (*10*), updating this model, estimated that a 10-percent increase in farm input prices would reduce nominal net farm income 9 percent in short run, but would raise net farm income as much as 17 percent in the long run.

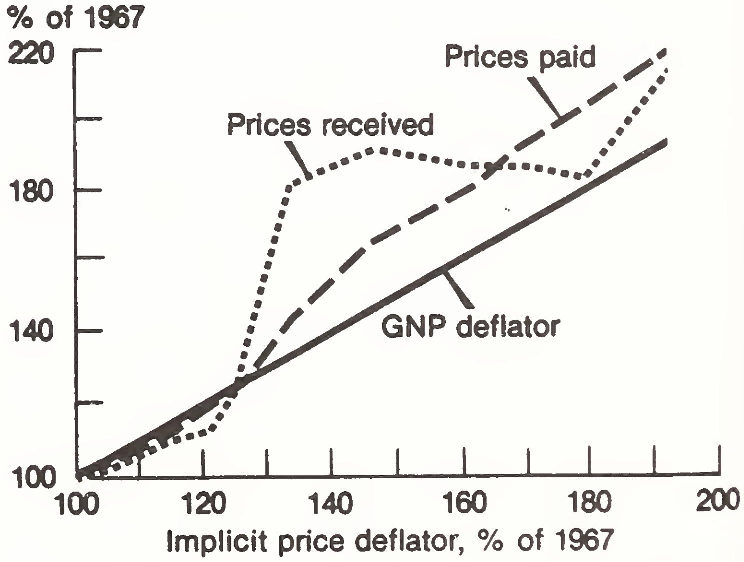
Other attempts to measure the effects of price changes on the farm sector during general price inflation have suggested that agriculture is always adversely affected. In a study which Ruttan characterizes as "the only rigorous empirical investigation of the effects of inflation on prices received and paid by farmers," Tweeten and Griffin (*10*) regressed the Farm Prices Received Index and Prices Paid by Farmers Index on the implicit GNP deflator and the lag of each variable for 1920-69. They observed a positive and significant relationship between the Prices Paid by Farmers Index and the implicit GNP deflator, but no significant relationship for the Prices Received Index. On this basis they concluded, "national inflation exerts a real price effect on the farming industry, reducing the parity ratio" (*10*, p. 10).

Because the Tweeten-Griffin results are based on price data similar to ours, yet arrive at the opposite conclusion, a further comparison of these two findings is in order. Some of the difference is explained by the different time periods. Tweeten and Griffin studied the 1920-69 period, whereas our study used the 1967-78 period. We suggest as an unproven hypothesis that the 1972-73 period, with its rapid expansion of agricultural exports and changes in the pricing policies of oil exporting countries, may have caused such fundamental shifts in relative price relationships as to invalidate many economic judgments for the post-1973 period, based on studies of time periods prior to 1972.

A second explanation is suggested by figure 8—that is, the Prices Received and Prices Paid by Farmers Indexes plotted

Figure 8

Farmers' Prices Received and Prices Paid Index Compared to the Implicit GNP Deflator



The first implication of our study, therefore, is to question the conventional wisdom about general price inflation having a negative real price effect on agriculture.

against the implicit GNP deflator. The prices paid line increases throughout the period and often nearly parallels the GNP deflator (45°) line. One would expect the Tweeten-Griffin result of a significant relationship between the Prices Paid by Farmers Index and the implicit GNP deflator. However, the Prices Received Index line both rises sharply and falls during the 1967-78 period and is hardly parallel. Again, one would expect the Tweeten-Griffin result of no significant relationship between the Prices Received Index and the implicit GNP deflator. But one would be misled by drawing a conclusion like Tweeten and Griffin's from these results: that is, general inflation reduces the parity ratio, because during this period, although the Prices Received Index varied too much to be signficiantly related to the GNP deflator, most of the variance was at a level above the GNP deflator.

Thus, during the 1967 period, while the general price level as measured by the GNP deflator rose each year and the rise totaled 92 percent, the parity ratio (1967 = 100) did not fall in 4 of the 11 years and fell only 4 percent over the 11-year period. The Tweeten-Griffin equations would have predicted an 8-percent drop, if one uses their insignificant coefficient in the Prices Received equation, and would have predicted a somewhat larger drop, assuming no relationship between the Prices Received Index and the GNP deflator. In 3 of the 4 years, the parity ratio did not fall; it rose 5 percent or more. The Tweeten-Griffin analysis does not consider the fact that, in recent times, supply and demand shocks on farm output prices have enhanced rather than depressed prices.

The first implication of our study, therefore, is to question the conventional wisdom about general price inflation having a negative real price effect on agriculture.

The proposed relative income index adds an analytical tool which measures the effect of relative price changes in greater detail than can the parity ratio. Our model allows the analyst to consider relative price effects on nonfarm sectors of the economy by keeping the individual sector measures consistent with national aggregate measures.

Ordinary price indexes are likely to mislead because they reflect only prices received or paid, but not both. The relative income index reflects net income after adjusting for prices received and paid by an individual sector.

Our model also demonstrates the effects of relative price changes on different sectors of the food system. Considering inflationary effects on either the food system or the farm sector masks the diversity in relative prices at the commodity and industry level.

Because inflation distorts investment decisions, capital values, and other time-related economic variables, the relative price effects presented here provide the policymaker with unique economic data. These effects are derived only from current flows from current production; thus, the relative measures of effects of relative price changes are not distorted by investment, cash flow, tax effects, and other time-related distortions.

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Beyond Expected Utility: Risk Concepts for Agriculture from a Contemporary Mathematical Perspective

Michael D. Weiss

Abstract. *Expected utility theory, the most prominent economic model of how individuals choose among alternative risks, exhibits serious deficiencies in describing empirically observed behavior. Consequently, economists are actively searching for a new paradigm to describe behavior under risk. Their mathematical tools, such as functional analysis and measure theory, reflect a new, more sophisticated approach to risk. This article describes the new approach, explains several of the mathematical concepts used, and indicates some of their connections to agricultural modeling.*

Keywords. *Individual choice under risk, expected utility theory, risk preference ordering, utility function on a lottery space, Fréchet differentiability, random function, random field.*

In their attempts to model individual behavior under risk, agricultural economists have relied heavily on the expected utility hypothesis. This hypothesis stipulates that individuals presented with a choice among various risky options will choose one that maximizes the mathematical expectation of their personal "utility." An accumulation of evidence reported in the literatures of both economics and psychology, however, has by now clearly demonstrated that expected utility theory exhibits serious deficiencies in describing empirically observed behavior. (For reviews, see Schoemaker, 1982; Machina, 1983, 1987; Fishburn, 1988.)[1] As a result, economists and psychologists have been formulating and testing new theories to describe behavior under risk. These theories do not so much deny classical expected utility theory as generalize it. By imposing weaker restrictions on the functional forms used in risk models, they allow empirical behavior more scope in telling its own story.

To a significant extent, this search for a new paradigm of behavior under risk is being conceived and conducted in the spirit and language of contemporary mathematics. The concepts being employed, such as the derivative of a functional with respect to a probability distribution or vector spaces whose "points" are functions, cannot be reduced to the graphical analysis traditionally favored by applied economists. Rather, they involve a genuinely new approach, a way of thinking that is at the same time more precise and more abstract.

This article is intended to provide agricultural and applied economists with an introduction to these newer ways of thinking about behavior under risk. Designed to be largely self-contained, the article first sketches some prerequisites from set theory and measure theory, then defines and discusses several key risk concepts from a modern perspective.

On the surface, the mathematical ideas we describe may appear distant from direct practical application. Yet, they already play an important role in various theories on which practical applications have been or can be based. Some examples:

- **Commodity futures and options.** A revolution in the theory of finance, begun in the 1970's and continuing today, has been brought about by the adoption of advanced mathematical tools, such as continuous stochastic processes, the Black-Scholes option pricing formula, and stochastic integrals (used to represent the gains from trade). The insights afforded by these methods have had a substantial practical impact on securities trading. Understanding commodity futures and options trading in this new environment requires greater familiarity with the new mathematical machinery. This machinery, in turn, draws heavily on measure theory, which is now a prerequisite for advanced finance theory (Dothan, 1990; Duffie, 1988).

- **Commodity price stabilization.** In recent years, economists increasingly have drawn on the techniques of stochastic dynamics to analyze the behavior of economic processes over time. Applications of stochastic dynamics range from the optimal management of renewable resources, such as timber, to optimal firm investment strategies. For agricultural

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[1]Sources are listed in the References section at the end of this article.

economists, a particularly important application is the construction of policy models of commodity price stabilization (Newbery and Stiglitz, 1981). Such models often portray a stochastic sequence of choices by both producers and policymakers. In every time period, each side must confront not only uncertain future prices and yields, but the uncertainties of the other's future actions. An understanding of this subject requires concepts of dynamics, probability, and functional analysis.

Modern treatments of stochastic dynamics (Stokey and Lucas, 1989) couch their explanations in the language of sets and functions. We describe and use this language in this article. We also describe Fréchet differentiability, a generalization of ordinary differentiability that allows consideration of the rate of change of one function with respect to another. Fréchet differentiability not only is important in risk theory (Machina, 1982) but has been invoked in the field of dynamic analysis (Lyon and Bosworth, 1991) to argue for a reassessment of some of the received dynamic theory (Treadway, 1970) cited by agricultural economists in interpreting empirical results (Vasavada and Chambers, 1986; Howard and Shumway, 1988).

- **The modeling of information.** The information available to individuals plays a pivotal role in their economic behavior. Thus, in analyzing such subjects as food safety, crop insurance, and the purchase of commodities of uncertain quality, economists must somehow incorporate this intangible entity, information, into their models. We will describe two approaches to dealing with this problem. First, we will introduce the notion of a Borel field of sets. This seemingly abstruse tool is now fundamental to finance theory, where increasing families of Borel fields are used to represent the flow of information available to a trader over time. Second, we will discuss how the choice set of an economic agent's risk preference ordering can be used to distinguish between situations of certainty and uncertainty.

- **The measurement of individuals' risk attitudes.** A question of both theoretical and empirical interest in the risk literature, one whose answer is important for the practical elicitation of risk preferences, is whether individuals' utility functions for risky choices are (a) determined by, or (b) essentially separate from, their utility functions for riskless choices. It has been widely assumed that case (a) prevails within expected utility theory. We will show, however, that within this theory, the utility function for continuous probability distributions can be constructed independently of the utility function for riskless choices. Thus, expected utility theory permits more flexible functional forms than perhaps generally realized. If an individual uses distinct rules for choosing among certainties and among continuous probability distributions, the expected utility paradigm may still be applicable.

Mathematical Preliminaries

The starting point for a clear understanding of risk is a clear understanding of the basic mathematical objects (random variables, probability spaces, and so forth) in terms of which risk is discussed and modeled. Since much of contemporary risk theory is described in the language of set theory, we first review some basic terminology from that subject.

The notation "$s \in S$" indicates that s is an element of the set S, while the brace notation "$\{2,5,3\}$" defines $\{2,5,3\}$ as a set whose elements are 2, 5, and 3. Two sets are equal if and only if they contain the same elements. Thus, $\{5,2,3,3\}$ is equal to $\{2,5,3\}$; the order of listing is immaterial as is the appearance of an element more than once. The set of all x such that x satisfies a property P is denoted $\{x \mid P(x)\}$. Thus, within the realm of real numbers, $\{x \mid x^2 = 1\}$ is the set $\{-1,1\}$. There is a unique set, called the *empty* set and denoted $\varnothing$, that contains no elements.

For any sets A_1 and A_2, their *intersection*, $A_1 \cap A_2$, is the set $\{x \mid \text{for each } i,\ x \in A_i\}$, their *union*, $A_1 \cup A_2$, is $\{x \mid \text{for at least one } i,\ x \in A_i\}$, and their *difference*, $A_1 \setminus A_2$, is $\{x \mid x \in A_1 \text{ and not } x \in A_2\}$. The definitions of union and intersection extend straightforwardly to any finite or infinite collection of sets. A set A_1 is a *subset* of a set A_2 if each element of A_1 is an element of A_2.

A set of the form $\{\{a\},\{a,b\}\}$ is called an *ordered pair* and denoted (a,b). The essential feature of ordered pairs, that $(a,b) = (c,d)$ if and only if $a = c$ and $b = d$, is easily demonstrated. If A and B are sets, their *Cartesian product*, $A \times B$, is the set of all ordered pairs (a,b) for which $a \in A$ and $b \in B$. The extension to ordered n-tuples $(a_1,\ldots,a_n)$ and n-fold Cartesian products $A_1 \times \ldots \times A_n$ is straightforward.

A *relation* is a set of ordered pairs. If R is a relation, the set $\{x \mid \text{for some } y\ (x,y) \in R\}$ is called the *domain* of R (denoted D_R), and the set $\{y \mid \text{for}$

some x $(x,y) \in R\}$ is called the *range* of R (denoted R_R). A *function* (or *mapping*) is a relation for which no two distinct ordered pairs have the same first coordinate. When f is a function and $(x,y) \in f$, y is denoted f(x) and called the *value* of f at x. Symbolism like $f: A \to B$ (read "f maps A into B") indicates that f is a function whose domain is A and whose range is a subset of B.

Finally, if c is a number and f,g are real-valued functions having a common domain D, then cf and f + g are functions defined on D by $[cf](x) = cf(x)$ and $[f+g](x) = f(x) + g(x)$ for each $x \in D$. If f and g are *any* functions, then $f \circ g$, the *composition* of f and g (in that order), is the function defined by $[f \circ g](x) = f\big(g(x)\big)$ for each x in the domain $D_{f \circ g} \equiv \{x \mid x \in D_g \text{ and } g(x) \in D_f\}$.

Representations of Risk

As Stokey and Lucas (1989) point out, measure theory, which has served as the mathematical foundation of the theory of probability since the 1930's, is rapidly becoming the standard language of the economics of uncertainty. We sketch a few of the basic ideas of this subject.

Borel Fields of Events

In probability theory, the events to which probabilities are assigned are represented as subsets of a sample space of possible outcomes. Thus, in the toss of a standard, six-sided die, the event "an even number comes up" would be represented as the subset {2,4,6} of the sample space {1,2,3,4,5,6}. However, it is not logically possible, in general, to assign a probability to every subset of a sample space. To see why, imagine an ideal mathematical dart thrown randomly, according to a uniform probability distribution, into the interval [0,1]. The probability of hitting the subinterval [3/5,4/5] would be 1/5. Likewise, the probability of hitting any other subset of [0,1] would seem to be its length. But, there are subsets of [0,1], called nonmeasurable, that *have* no length. To construct an example, define any two numbers in [0,1] as "equivalent" if their difference is rational. This equivalence relation partitions [0,1] into a union of disjoint equivalence sets analogous to the indifference sets of demand theory. Choose one number from each equivalence set. Then, the set of these choices is nonmeasurable (see Natanson, 1955, pp. 76-78.)

Thus, some subsets cannot be assigned a probability in the situation we have described. One cannot assume, therefore, that every subset of an arbitrary sample space can be assigned a probability. Rather, in every risk model, the question of which subsets of the sample space are admissible must be addressed individually.

A set of admissible subsets of a sample space is characterized axiomatically as follows. Let Ω be a set (interpreted as a sample space) and F a collection (that is, a set) of subsets of Ω such that (1) $\Omega \in F$, (2) $\Omega \backslash A \in F$ whenever $A \in F$, and (3) $\bigcup_{i=1}^{\infty} A_i \in F$ whenever $\{A_i\}_{i=1}^{\infty}$ is a sequence of elements of F. Then, F is called a *Borel field*. F plays the role of a collection of events to which probabilities can be assigned. By ensuring that F is closed under various set-theoretic operations on the events in it, conditions 1-3 guarantee that certain natural logical combinations of events in F will also be in F. For example, application of 1-3 to the set-theoretic identity $A \cap B = \Omega \backslash [(\Omega \backslash A) \cup (\Omega \backslash B)]$ implies that $A \cap B$, the event whose occurrence amounts to the joint occurrence of A and B, is in F whenever A and B are.

Borel fields have an interpretation as "information structures" in the following sense. For simplicity, let the sample space Ω be the interval [0,1], let F be the smallest Borel field over Ω that includes among its elements the intervals [0,1/2) and [1/2,1] (so that $F = \{\varnothing, [0,1/2), [1/2,1], [0,1]\}$), and let F' be the smallest Borel field over Ω that includes among its elements the intervals [0,1/4), [1/4,1/2), and [1/2,1] (so that $F' = \{\varnothing, [0,1/4), [1/4,1/2), [1/2,1], [0,1/2), [1/4,1], [0,1/4) \cup [1/2,1], [0,1]\}$). Suppose an outcome ω_0 in Ω is realized, but all that is to be revealed to us is the identity of an event in F that has thereby occurred (that is, the identity of an event $E \in F$ for which $\omega_0 \in E$). Then, the most that we could potentially learn about the location of ω_0 in Ω would be either that ω_0 lies in [0,1/2) or that ω_0 lies in [1/2,1]. However, if we were instead to be told the identity of an event in F' that has occurred, we would have the possibility of learning certain additional facts about ω_0 not available through F. For example, we might learn that the event [0,1/4) in F' has occurred, so that $\omega_0 \in [0,1/4)$.

Observe that, in this example, F' contains every event in F and additional events not in F. That is, F is a strict subset of F'. Thus, F' offers a richer supply of events to help us home in on the realized state of the world, ω_0. In this sense, whenever any Borel field is a subset of another, the second may be interpreted to be at least as informative as (and, in the case of strict inclusion, more informative than) the first.

A particularly important Borel field over the real line $\mathbb{R}$ is denoted B and defined as follows. First,

note that the set of all subsets of $\mathbb{R}$ is a Borel field that contains all intervals as elements. Second, observe that the intersection of any number of Borel fields over the same set is itself a Borel field over that set. Define B as the intersection of *all* Borel fields over $\mathbb{R}$ that contain all intervals as elements. Then, B is itself a Borel field over $\mathbb{R}$ containing all intervals as elements. Moreover, it is the "smallest" such Borel field, since it is a subset of each such Borel field. The elements of B are known as *Borel sets*.

Probability Measures and Probability Spaces

Let P be a nonnegative real-valued function whose domain is a Borel field F over a set Ω. Then, P is called a *probability measure* on Ω and Ω (or, alternatively, the triple (Ω,F,P) is called a *probability space* if (1′) $P(\Omega) = 1$ and (2′) $P(\bigcup_{i=1}^{\infty} A_i) = \sum_{i=1}^{\infty} P(A_i)$ whenever $\{A_i\}_{i=1}^{\infty}$ is a sequence of elements of F that are pairwise disjoint (that is, for which $i \neq j$ implies $A_i \cap A_j = \emptyset$). Condition 2′ asserts that the probability of the occurrence of exactly one event out of a sequence of pairwise incompatible events is the sum of the individual probabilities. Probability measures on $\mathbb{R}$ having domain B are called *Borel* probability measures.

Random Variables

Finally, suppose (Ω,F,P) is a probability space and r a real-valued function with domain Ω. Then, r is called a *random variable* if, for every Borel set B in $\mathbb{R}$, $\{\omega \mid \omega \in \Omega \text{ and } r(\omega) \in B\} \in F$. (A function r satisfying this condition is said to be *measurable* with respect to F.) The effect of the measurability condition is to ensure that a situation like "random crop yield will lie in the interval I" corresponds to an element of F and can thus be assigned a probability by P.

A random variable measurable with respect to a Borel field F can be interpreted as depending only on the information inherent in F. For example, in finance theory, the flow of information over a time interval $[0,T]$ is represented by a family of Borel fields F_t $(0 \leq t \leq T)$ satisfying (among other conditions) the requirement that F_s be a subset of F_t whenever $s \leq t$ (information is nondecreasing over time). Correspondingly, the moment-to-moment price of a commodity is represented by a family of random variables p_t $(0 \leq t \leq T)$ such that, for each t, p_t is measurable with respect to F_t. In this manner, the price at time t is portrayed as depending only on the information available in the market at that time. (For additional details, see Dothan, 1990). Similarly, in stochastic dynamic policy models, a decisionmaker's contingent decisions over time are represented by a family of random variables r_t related to an increasing family of Borel fields F_t by the requirement that each r_t be measurable with respect to F_t.

Notwithstanding its name, a random variable is not random, and it is not a variable. It is a function, a set of ordered pairs of a certain type. Randomness or variability are aspects not of random variables themselves but, rather, of the *interpretations* we imagine when we use random variables to model real phenomena. For example, when we model a farmer's crop yield, we use a random variable (hence, a function), r, to represent *ex ante* yield, but we use a function *value*, $r(\omega)$, to represent *ex post* yield. What determines ω? We interpret nature as having "randomly" selected ω from the probability space on which r is defined.

Agricultural economists often represent stochastic production through forms such as $f(x) + \varepsilon$, where $x \in \mathbb{R}^n$ is interpreted as a vector of inputs and ε is interpreted as a random disturbance. Despite superficial appearances, such a construct is not a sum of a production function and a random variable. Rather, it is a *random field* (Ivanov and Leonenko, p. 5). To characterize it in precise terms, suppose f is a (production) function and ε a random variable. Define a function Φ having domain $D_\varepsilon \times D_f$ by $\Phi((\omega,x)) = f(x) + \varepsilon(\omega)$ for each $\omega \in D_\varepsilon$ and each $x \in D_f$. Then, Φ is a formal representation of stochastic production with additive error, and various functions defined in terms of Φ represent specific aspects of stochastic production. For example, for each $x \in D_f$, the random variable $\Phi(\cdot,x)$ defined on D_ε by $[\Phi(\cdot,x)](\omega) = \Phi((\omega,x))$ represents *ex ante* production under the input x. Similarly, for each $\omega \in D_\varepsilon$, the function $\Phi(\omega,\cdot)$ defined on D_f by $[\Phi(\omega,\cdot)](x) = \Phi((\omega,x))$ represents the effect of input choice on *ex post* production (that is, on the particular *ex post* production associated with nature's random "selection" of ω).

Another example of a random field is provided by the idea of signaling in principal-agent theory (Spremann, 1987, p. 26). Suppose the effort expended by an economic agent (for instance, the effort expended by a producer to ensure the safety of food) is unobservable by the principal (here, the consumer), but some "noisy function of" the effort *can* be observed. Such a signal of hidden effort may be defined formally as follows. Let h be the (real-valued) observer function (its domain is the set of allowable effort levels) and let ε be a random variable. Then, the function $z: D_h \times D_\varepsilon \to \mathbb{R}$ defined for each $e \in D_h$, $\omega \in D_\varepsilon$ by $z(e,\omega) = h(e) + \varepsilon(\omega)$ is a

random field that serves as a monitoring signal of effort.

When a risk situation can be represented by a random variable, it can equally well be represented by infinitely many distinct random variables. (For example, there exist infinitely many distinct normal random variables having mean 0 and variance 1, each defined on a different probability space.) For this reason, random variables cannot model situations of risk uniquely. However, to every random variable r defined on a probability space $(\Omega,\mathcal{F},P)$, there corresponds a unique Borel measure, P_r, on $\mathbb{R}$ satisfying $P_r(B) = P(\{\omega \mid \omega \in \Omega \text{ and } r(\omega) \in B\})$ for each Borel set B. (P_r is called the *probability distribution* of r.) In addition, there corresponds a unique function F_r: $\mathbb{R} \to [0,1]$, the *cumulative distribution function* (*c.d.f.*) of r, such that $F_r(t) = P(\{\omega \mid \omega \in \Omega \text{ and } r(\omega) \leq t\})$ for each $t \in \mathbb{R}$. P_r and F_r contain the same probabilistic information as r, but in a form more convenient for certain computational purposes.

The c.d.f. of a random variable r is always (1) nondecreasing and (2) continuous on the right at each point of $\mathbb{R}$. In addition, (3) $\lim_{t \to -\infty} F_r(t) = 0$ and $\lim_{t \to \infty} F_r(t) = 1$. Conversely, any function F: $\mathbb{R} \to [0,1]$ enjoying properties 1-3 can be shown to be the c.d.f. of some random variable. Thus, we are free to view the set of all c.d.f.'s as simply the set of all functions F: $\mathbb{R} \to [0,1]$ satisfying 1-3.

Random Functions

Random variables, Borel measures, and c.d.f.'s are tools for representing the chance occurrence of scalars. They can be generalized to n-dimensional random vectors, probability measures on $\mathbb{R}^n$, and n-dimensional c.d.f.'s to represent the chance occurrence of vectors in $\mathbb{R}^n$. However, even more general tools are sometimes needed for the conceptualization of risk in agriculture. For example, the yield of a corn plant depends on, among other things, the surrounding temperature over the period of growth. It is reasonable to express this temperature as a real-valued function, τ, defined on some time interval, [0,t]. Yet τ, as a constituent of weather, must be regarded as determined by chance. Thus, the probability distribution of the plant's yield depends on the probability distribution by which nature "selects" the temperature function. Just as the probability distribution of a random variable is a probability measure defined on a set of numbers, this notion of the probability distribution of a random function finds its natural expression in the form of a probability measure defined on a probability space of functions.

Similarly, consider stochastic crop production, CP_L, over a region, L, in the plane $\mathbb{R}^2$. Since yield, like weather, can vary over a region, it is appropriate to define CP_L not merely as the traditional "acreage times yield" but, rather, as the integral over L of a yield (or production density) function defined at each point of L. That is, suppose Ω is a probability space representing weather outcomes, X a set of input vectors, and Y: $\Omega \times X \times L \to \mathbb{R}_+$ a stochastic pointwise yield function such that, for each choice $x \in X$ of inputs and each location $\lambda \in L$, the function $Y(\cdot,x,\lambda)$: $\Omega \to \mathbb{R}_+$ (interpreted as the *ex ante* yield at the location λ given input choice x) is a random variable.[2] Then, for each weather outcome $\omega \in \Omega$, the corresponding *ex post* crop production over L given input vector x can be expressed as $CP_L(\omega,x) = \int_L Y(\omega,x,\lambda)d\lambda$ whenever the integral exists. However, the integrand (the *ex post* pointwise yield function $Y(\omega,x,\cdot)$: $L \to \mathbb{R}_+$) is determined by chance, since it is parameterized by ω. Thus, the probability distribution (if it exists) of $CP_L(\cdot,x)$, that is, of *ex ante* production over L given x, depends on the probability distribution by which nature selects the integrand. The latter notion is, again, expressed naturally by a probability measure defined on a probability space of functions, in this case functions mapping the region L into $\mathbb{R}$.

Individual Choice Under Risk

Like the theory of consumer demand, the theory of choice under risk begins with an ordering that expresses an individual's preferences among the elements of a designated set. In demand theory, that set consists of vectors representing commodity bundles. In risk theory, it consists of mathematical constructs (random variables, c.d.f.'s, probability measures, or the like) capable of representing situations of risk.

Preference Orderings

Suppose $\succcurlyeq$ is a relation such that $D_{\succcurlyeq} = R_{\succcurlyeq}$ (in which case $\succcurlyeq$ is a subset of $D_{\succcurlyeq} \times D_{\succcurlyeq}$ and relates elements of $D_{\succcurlyeq}$ to elements of $D_{\succcurlyeq}$). Write $a \succcurlyeq b$ to signify that $(a,b) \in \succcurlyeq$. Then, $\succcurlyeq$ is called a *preference ordering* if it is complete (that is, $a \succcurlyeq b$ or $b \succcurlyeq a$ for any elements a,b of $D_{\succcurlyeq}$) and transitive (that is, for any elements a,b,c of $D_{\succcurlyeq}$, $a \succcurlyeq c$ whenever $a \succcurlyeq b$ and $b \succcurlyeq c$). When $\succcurlyeq$ is a preference ordering, the assertion $a \succcurlyeq b$ is read "a is weakly preferred to b" and interpreted to mean that the economic agent either prefers a to b or is indifferent between a and b.

[2]Y constitutes our third example of a random field.

Though individuals' preferences are often considered empirically unobservable, there is nothing indefinite about the *concept* of a preference ordering. In contemporary economic theory, preference orderings are mathematical objects, and they can be examined, manipulated, and compared as such. For example, $\geqslant$, the ordinary numerical relation "greater than or equal to," is a preference ordering of $\mathbb{R}$. Formally, as a set of ordered pairs, it is simply the closed half-space lying below the line $y = x$ in the plane $\mathbb{R} \times \mathbb{R} = \mathbb{R}^2$. Thus, it can be compared as a geometric object to other subsets of $\mathbb{R}^2$ that signify preference orderings of $\mathbb{R}$. This geometric perspective can be invoked in investigating whether two preference orderings are the same, whether they are near one another, and so forth. Similarly, preference orderings of other sets S, including sets of c.d.f.'s or other representations of risk, can be studied as geometric objects in $S \times S$. In this context is to be found the formal meaning (if not the econometric resolution) of such empirical questions as "have consumer preferences for red meat changed?" or "are poor farmers more risk averse than wealthy farmers?"

Lotteries and Convexity

What properties are appropriate to require of a set of risk representations before a preference ordering of it can be defined? Expected utility theory imposes only one restriction: the set of risk representations must be closed under the formation of compound lotteries.

A "lottery" may be viewed as a game of chance in which prizes are awarded according to a preassigned probability law. Suppose a lottery L offers prizes L_1 and L_2 having respective probabilities p and $1 - p$ of occurring. If L_1 and L_2 are themselves lotteries, L is called a *compound* lottery.

Consider a farmer whose crops face an insect infestation having probability p of occurring. Assume weather to be random. Then, the farmer would receive one income distribution with probability p, another with probability $1 - p$. This situation has the form of a compound lottery.

What expected utility theory requires of the domain of a preference ordering is that whenever two lotteries with monetary prizes lie in the domain, any compound lottery formed from them must lie in it as well. Now, mathematically, lotteries L_1, L_2 with numerical prizes can be represented by c.d.f.'s C_1, C_2. If the internal structure of a compound lottery is ignored and only the distribution of the lottery's final numerical prizes is considered, then the compound lottery L offering L_1 and L_2 as prizes with probabilities p and $1 - p$ is represented by the c.d.f. $pC_1 + (1-p)C_2$. Thus, the requirement that the domain of a preference ordering be closed under compounding is expressed formally by the requirement that, whenever c.d.f.'s C_1, C_2 lie in the domain, any convex combination $pC_1 + (1-p)C_2$ of them must lie in it as well. However, within the vector space over $\mathbb{R}$ of all functions mapping $\mathbb{R}$ into $\mathbb{R}$ (Hoffman and Kunze, 1961, pp. 28-30), $pC_1 + (1-p)C_2$ is nothing but a point on the line segment joining C_1 and C_2. Thus, this entire line segment is required to lie in the domain whenever its endpoints do. In short, the domain is required to be convex (Kreyszig, 1978, p. 65).

The ability of c.d.f.'s to represent compound lotteries as convex combinations is shared by Borel probability measures but not by random variables. Thus, expected utility theory and the related risk literature usually deal with c.d.f.'s or probability measures rather than random variables. Formally, the term *lottery* is commonly used to denote either a c.d.f. or a probability measure, depending on context. For this article, we define a lottery to be a c.d.f. A *lottery space* is a convex set of lotteries. By a *risk preference ordering*, we mean a preference ordering whose domain is a lottery space.

Keep in mind that not all situations of individual choice in the presence of risk are appropriately modeled by the simple optimization of a risk preference ordering. Risk preference orderings are intended to compare risks and risks only. By contrast, a consumer's decision whether to obtain protein through consumption of peanut butter (a potential source of aflatoxin) or chicken (a potential source of salmonella) involves questions of taste as well as risk. Unless these influences can be separated, standard risk theories—expected utility or otherwise—will not apply.

Choice Sets and the Modeling of Information

As a result of budget constraints or other restrictions dictated by particular circumstances, an individual's choices under risk will generally be confined to a strict subset of the lottery space $D_{\geqslant}$ termed the choice set. It is this set on which are ultimately imposed a model's assumptions concerning what is known versus unknown, certain versus uncertain to the economic agent.

Several areas of concern to agricultural economists—food safety, nutrition labeling, grades and standards, and product advertising—are intimately tied to the economics of information (and, by extension, to the economics of uncertainty). The inability of consumers to detect many food contami-

nants unaided, for example, limits producers' economic incentives to compete on the basis of food safety. Government policy aims both to reduce risks to consumers and to provide information about what risks do exist. How, though, can assumptions about, or changes in, a consumer's information or uncertainty be incorporated explicitly into a mathematical model? The agent's choice set would often appear to be the proper vehicle for representing these factors. For example, when the agent is assumed to be choosing under certainty, the choice set is confined to constructs representing certainties, such as c.d.f.'s of constant random variables. When the agent is assumed to be choosing under risk, representations of certainty are *excluded* from the choice set, and only those lotteries are allowed that conform to the economic and probabilistic assumptions of the model. The choice set of lotteries in a model of behavior under risk plays no less important a role than the set of feasible, budget-constrained commodity bundles in a model of consumer demand. In each case, the optimum achieved by the economic agent is crucially dependent on the set over which preferences are permitted to be optimized.

Utility Functions on Lottery Spaces

Let $\succcurlyeq$ be a risk preference ordering. A function U: $D_{\succcurlyeq} \to \mathbb{R}$ is called a *utility function* for $\succcurlyeq$ if, for any elements a,b of $D_{\succcurlyeq}$, $U(a) \geq U(b)$ if and only if $a \succcurlyeq b$. A function U: $D_{\succcurlyeq} \to \mathbb{R}$ is called *linear* if $U\big(tL_1 + (1-t)L_2\big) = tU(L_1) + (1-t)U(L_2)$ whenever $L_1, L_2 \in D_{\succcurlyeq}$ and $0 \leq t \leq 1$.

Linearity in the above sense must be distinguished from the notion of linearity customarily applied to mappings defined on vector spaces (Hoffman and Kunze, 1961, p. 62). Indeed, a lottery space cannot be a vector space since, for example, the sum of two c.d.f.'s is not a c.d.f. Rather, the assumption that a function U: $D_{\succcurlyeq} \to \mathbb{R}$ is linear in our sense is analogous to the assumption that a function g: $\mathbb{R} \to \mathbb{R}$ has a straight-line graph, that is, that g is both concave ($g(\lambda x + (1-\lambda)y) \geq \lambda g(x) + (1-\lambda)g(y)$ whenever $x, y \in D_g$ and $0 \leq \lambda \leq 1$) and convex ($g(\lambda x + (1-\lambda)y) \leq \lambda g(x) + (1-\lambda)g(y)$ whenever $x, y \in D_g$ and $0 \leq \lambda \leq 1$), or, equivalently, that $g(\lambda x + (1-\lambda)y) = \lambda g(x) + (1-\lambda)g(y)$ whenever $x, y \in D_g$ and $0 \leq \lambda \leq 1$.[3] Restated for a function U: $D_{\succcurlyeq} \to \mathbb{R}$, the latter condition expresses precisely the concept of linearity introduced above.

An assumption of linearity requires, in effect, that a compound lottery be assigned a utility equal to the expected value of the utilities of its lottery prizes. Though stated for a convex combination of two lotteries, the formula in the definition of linearity is easily shown to extend to a convex combination of n lotteries. For example, we can use the convexity of $D_{\succcurlyeq}$ to express $p_1L_1 + p_2L_2 + p_3L_3$, a convex combination of three elements of $D_{\succcurlyeq}$, as a convex combination of *two* elements of $D_{\succcurlyeq}$, obtaining (under the conventions $p_2 + p_3 \neq 0$, $p_2' \equiv p_2/(p_2+p_3)$, $p_3' \equiv p_3/(p_2+p_3)$):

$$\begin{aligned}
U(p_1L_1 &+ p_2L_2 + p_3L_3) \\
&= U\big(p_1L_1 + (p_2+p_3)(p_2'L_2 + p_3'L_3)\big) \\
&= p_1U(L_1) + (p_2+p_3)U(p_2'L_2 + p_3'L_3) \\
&= p_1U(L_1) + (p_2+p_3)p_2'U(L_2) + (p_2+p_3)p_3'U(L_3) \\
&= p_1U(L_1) + p_2U(L_2) + p_3U(L_3).
\end{aligned}$$

A similar argument applied recursively to a convex combination of n elements of $D_{\succcurlyeq}$ can be used to establish the general case.

Utility functions allow questions about risk preference orderings to be recast into equivalent questions about real-valued functions defined on lottery spaces. The benefit of this translation is most apparent when the utility function can itself be expressed in terms of another "utility function" that maps not lotteries to numbers but *numbers* to numbers, for then the techniques of calculus can be applied. It is on utility functions of the latter type that the attention of agricultural economists is usually focused.

Although such wholly numerical utility functions are frequently described as "von Neumann-Morgenstern" utility functions, von Neumann and Morgenstern (1947) were concerned with assigning utilities to lotteries, not numbers. Using a very general concept of lottery, they demonstrated that any risk preference ordering satisfying certain plausible behavioral assumptions can be represented by a linear utility function. They did not prove, nor does it follow from their assumptions, that a linear utility function, U, must give rise to a numerical function u such that the utility of an arbitrary lottery L has an expected utility integral representation of the form $U(L) = \int_{-\infty}^{\infty} u(t)dL(t)$.

Conditions guaranteeing that a linear utility function has an integral representation of this type were given by Grandmont (1972). However, one of these conditions fails to hold for the lottery space of all c.d.f.'s having finite mean, which is a natural lottery space on which to consider risk aversion.

Numerical Utility Functions

What is the general relationship between numerical utility functions and the more fundamental utility

[3]Such a function g is linear as a vector space mapping if and only if $g(0) = 0$.

functions defined on lottery spaces? To examine this question, we introduce the following definitions.

For each $r \in \mathbb{R}$, the lottery δ_r defined by:

$$\delta_r(t) = \begin{cases} 0 \text{ if } t \leq r \\ 1 \text{ if } t > r \end{cases}$$

is called *degenerate*. δ_r is the c.d.f. of a constant random variable with value r. Thus, it represents "r with certainty."

Suppose U is a utility function for a risk preference ordering $\succcurlyeq$ whose domain, $D_{\succcurlyeq}$, contains all degenerate lotteries. Define a function u: $\mathbb{R} \to \mathbb{R}$ by:

$$u(r) = U(\delta_r),$$

for each $r \in \mathbb{R}$. We call u the *utility function induced on* $\mathbb{R}$ *by* U. u is a numerical function that, importantly, encapsulates the action of U under certainty.

A lottery L is called *simple* if it is a convex combination of a finite number of degenerate lotteries, that is, if there exist degenerate lotteries $\delta_{r_1}, \ldots, \delta_{r_n}$ and nonnegative numbers $p_1, \ldots, p_n$ such that $\sum_{i=1}^{n} p_i = 1$ and $L = \sum_{i=1}^{n} p_i\delta_{r_i}$. In this case, L is the c.d.f. of a random variable taking the value r_i with probability p_i ($i = 1, \ldots, n$).

Now, let U be a linear utility function whose domain contains all degenerate lotteries. Then u, the utility function induced on $\mathbb{R}$ by U, is defined. Moreover, by the convexity property of a lottery space, the domain of U contains all simple lotteries. Consider any simple lottery $L \equiv \sum_{i=1}^{n} p_i\delta_{r_i}$, and let X be a random variable whose c.d.f. is L. Then, the composite function $u \circ X$ is a random variable taking the value $u(r_i)$ with probability p_i ($i = 1, \ldots, n$), and it follows that:

$$U(L) = \sum_{i=1}^{n} p_i U(\delta_{r_i})$$

$$= \sum_{i=1}^{n} p_i u(r_i)$$

$$= E(u \circ X),$$

that is, U(L) is the expected value of $u \circ X$.[4] However, unless additional restrictions (such as those of Grandmont (1972)) are imposed, U(L) cannot, in general, be expressed as the expectation of the induced utility function when L is *not* simple. In fact, a significant part of U is *independent* of its induced utility function and therefore independent of U's utility assignments under certainty. We turn next to this subject—the structural distinctness within a linear utility function of its "certainty part" and a portion of its "uncertainty part" (Weiss, 1987, 1992).

[4]In the applied literature, $u \circ X$ is often incorrectly identified with u. $u \circ X$ is a random variable, while u is not.

Decomposition of Linear Utility Functions

A linear utility function can be decomposed into a "continuous part" and a "discrete part." The latter encodes all aspects of U relating to behavior under certainty. Unless additional restrictions are imposed, the former is entirely independent of behavior under certainty.

To describe this decomposition satisfactorily, we require the following definitions. A lottery is called *continuous* if it is continuous as an ordinary function on $\mathbb{R}$. A lottery L is called *discrete* if it is a convex combination of a sequence of degenerate lotteries, that is, if there exist a sequence $\{\delta_{r_i}\}_{i=1}^{\infty}$ of degenerate lotteries and a sequence $\{p_i\}_{i=1}^{\infty}$ of nonnegative numbers such that $\sum_{i=1}^{\infty} p_i = 1$ and $L = \sum_{i=1}^{\infty} p_i\delta_{r_i}$. Such a lottery L is the c.d.f. of a random variable taking the value r_i with probability p_i ($i = 1, 2, 3, \ldots$). Every simple lottery (and thus every degenerate lottery) is discrete.

Now, every lottery L has a decomposition:

$$L = p_L L_c + (1-p_L)L_d,$$

such that $0 \leq p_L \leq 1$, L_c is a continuous lottery, and L_d is a discrete lottery (Chung, 1974, p. 9). (Such decompositions occur naturally in the economics of risk, as when an agricultural price support or other insurance mechanism truncates a random variable whose c.d.f. is continuous, leading to a "piling up" of probability mass at one point. See Weiss, 1987, pp. 69-70, or Weiss, 1988.) Moreover, p_L is unique, L_c is unique if $p_L \neq 0$, and L_d is unique if $p_L \neq 1$. It follows that if U is a linear utility function whose domain contains L, L_c, and L_d, then $U(L) = p_L U(L_c) + (1-p_L)U(L_d)$. Thus, U is entirely determined by its action on continuous lotteries and its action on discrete lotteries. If, moreover, the domain of U contains all degenerate lotteries and U is countably linear over such lotteries in the sense that $U(L) = \sum_{i=1}^{\infty} p_i U(\delta_{r_i})$ for any discrete lottery $L = \sum_{i=1}^{\infty} p_i\delta_{r_i}$ in its domain, then U

is entirely determined by its action on continuous lotteries and its action at certainties.

The foregoing remarks show how function values of U can be decomposed, but they do not indicate how U itself, as a function, can be decomposed. A full description of this functional decomposition cannot be given here. In brief, however, one uses the rule $U^*(pL) \equiv pU(L)$ to extend U to a new function, U^*, defined on an enlarged domain consisting of all product functions pL for which $0 \leq p \leq 1$ and $L \in D_U$ (such product functions are called *sublotteries*). Then (assuming $L \in D_U$ implies (1) $L_c \in D_U$ if $p_L \neq 0$ and (2) $L_d \in D_U$ if $p_L \neq 1$), U^* has a decomposition:

$$U^* = U_c^* + U_d^*,$$

into unique functions U_c^* and U_d^* that are defined and linear over sublotteries, map the zero sublottery to itself, and depend only on the continuous or discrete part, respectively, of a sublottery (see Weiss, 1987).

We have described how a linear utility function can be resolved into its continuous and discrete parts. Conversely, one can *construct* a linear utility function out of a linear utility function defined over continuous lotteries and a linear utility function defined over discrete lotteries. In fact, if V_1 is a linear function defined over all continuous lotteries and V_2 a bounded real-valued function defined over all degenerate lotteries, a function V can be defined at any lottery:

$$L = p_L L_c + (1-p_L) \sum_{i=1}^{\infty} p_i \delta_{r_i},$$

by the rule:

$$V(L) \equiv p_L V_1(L_c) + (1-p_L) \sum_{i=1}^{\infty} p_i V_2(\delta_{r_i}).$$

V will be a linear utility function for the preference ordering $\geq$ defined for all pairs of lotteries by: $L_1 \geq L_2$ if and only if $V(L_1) \geq V(L_2)$. In this manner, one can construct risk preference orderings for which the utilities assigned to continuous lotteries are independent of those assigned to certainties—in short, risk preference orderings for which, in appropriate choice sets, behavior under risk is independent of, and cannot be predicted from, behavior under certainty.

This construction provides a useful illustration of why the traditional, graphical approach to risk is inadequate: the graph of the utility function induced on $\mathbb{R}$ (by V) provides no information concerning, say, the individual's risk preferences among normal c.d.f.'s. One also sees from this construction that the utility function induced on $\mathbb{R}$ by a linear utility function need not itself be linear (in the sense of having a straight-line graph).

Risk Aversion

Risk aversion is a purely ordinal notion, a property of risk preference orderings. Suppose $\geq$ is a risk preference ordering such that each lottery, L, in $D_{\geq}$ has a finite mean, E(L), for which $\delta_{E(L)} \in D_{\geq}$. Then, $\geq$ is called *risk averse* if, for each $L \in D_{\geq}$, $\delta_{E(L)} \geq L$. That is, an individual is risk averse if a guaranteed payment equal to the expected value of a lottery is always (weakly) preferred to the lottery itself.

Risk aversion is often identified with the concavity of a numerical utility function, and this characterization plays an important role in applied risk studies. The techniques of the preceding paragraphs, however, demonstrate that the equivalence is not universally valid. Since a linear utility function can be constructed using independent selections of its induced utility function and its continuous part, it is easy to construct a risk preference ordering that is not risk averse but is represented by a linear utility function whose induced utility function is strictly concave. In addition, while risk aversion does indeed imply concavity of the induced utility function, it is nevertheless possible to construct a risk-averse preference ordering $\geq$, a linear utility function V representing $\geq$, and a numerical function v *strictly convex* on [0,1] such that, for any continuous lottery L on [0,1] (that is, for which L(0) = 0 and L(1) = 1), one has:

$$V(L) = \int_0^1 v(t)dL(t).$$

This example seems contrary to "common knowledge" about risk aversion, but its real lesson is that there is more to risk aversion and to other risk concepts than can be captured by the traditional approaches.

A correct description of the relationship between risk aversion and the concavity of numerical utility functions can be given using the concept of continuous preferences (Weiss, 1987, 1990). Let us call a utility function U for a risk preference ordering $\geq$ *continuous* if, for any lottery L in $D_{\geq}$ and any sequence $\{L_i\}_{i=1}^{\infty}$ of lotteries in $D_{\geq}$ converging to L in distribution (that is, for which $\lim_{i\to\infty} L_i(x) = L(x)$ for each point x at which L is continuous), one has $\lim_{i\to\infty} U(L_i) = U(L)$. We call a preference ordering continuous if it can be repre-

sented by a continuous utility function. Now, suppose $\succcurlyeq$ is a risk preference ordering represented by a linear utility function having an induced utility function u. Then, (1) if $\succcurlyeq$ is risk averse, u is concave, while (2) if u is concave *and* $\succcurlyeq$ *is continuous*, then $\succcurlyeq$ is risk averse. For proofs, see Weiss (1987).

Statement 2 shows that the assumption of continuous risk preferences is sufficient to ensure the equivalence between concave numerical utility functions and risk-averse preferences. Note, however, that continuity of $\succcurlyeq$ is not guaranteed by continuity of u. In fact, no assumption concerning u alone can guarantee the continuity of either U or $\succcurlyeq$ (Weiss, 1987). Rather, only through assumptions at a more abstract level, beyond the "visible" or "graphable" part of $\succcurlyeq$ or U embodied in u, can the continuity of risk preferences be assured. Here, again, we see the limitations of traditional approaches as a theoretical foundation for empirical risk analysis.

Beyond Linearity: Machina's "Generalized Expected Utility Theory"

Machina (1982) provided an important generalization of expected utility theory by showing that many of the results of the classical theory extend, in an approximate sense, to nonlinear utility functions. His findings, which have attracted attention among agricultural economists (note, for example, Machina, 1985), exemplify the contribution of modern mathematical concepts to risk theory.

At an intuitive level, Machina's work is grounded in the idea that a function $f: \mathbb{R} \to \mathbb{R}$ differentiable at a point x_0 is locally linear in the sense that the line tangent to the graph of f at $(x_0, f(x_0))$ approximates the graph near this point. That is, if $T_{x_0}: \mathbb{R} \to \mathbb{R}$ is the function whose graph is this tangent line, then T_{x_0} approximates f near x_0.

Machina exploited a simple but powerful idea: a differentiable utility function should also be locally linear. Since linearity of the utility function of a preference ordering is the essence of expected utility theory, such local linearity ought to impart at least local (and possibly global) expected utility-type properties to any smooth risk preference ordering, that is, to any risk preference ordering representable by a differentiable utility function.

What, though, is to be meant by the "differentiability" of a utility function of a preference ordering? After all, such functions are defined not on the real line or even on $\mathbb{R}^n$, but on a space of lotteries, of cumulative distribution functions. An answer is provided by the concept of "Fréchet differentiability" (Luenberger, 1969, p. 172; Nashed, 1966), the natural notion of differentiability for a real-valued function defined on a normed vector space (Kreyszig, 1978, p. 59). To motivate a definition, consider that ordinary differentiability of a function $f: \mathbb{R} \to \mathbb{R}$ at a point x_0 can be characterized by the following condition: there exists a continuous function $g: \mathbb{R} \to \mathbb{R}$, linear in the vector space sense (so that $g_{x_0}(tx+y) = tg_{x_0}(x) + g(y)$ and, in particular, $g_{x_0}(0) = 0$), such that:

$$\lim_{x \to x_0} \frac{f(x) - f(x_0) - g_{x_0}(x-x_0)}{x - x_0} = 0. \tag{1}$$

Indeed, when the stated condition holds, the restrictions on g imply that g must be of the form $g_{x_0}(x) = \alpha_{x_0}\, x$ for some $\alpha_{x_0} \in \mathbb{R}$, and equation (1) thus reduces to:

$$\lim_{x \to x_0} \frac{f(x) - f(x_0)}{x - x_0} = \alpha_{x_0},$$

implying the differentiability of f at x_0. Conversely, if f is differentiable at x_0, the above condition is satisfied by the function g_{x_0} defined by $g_{x_0}(x) = f'(x_0)x$.

The limit appearing in equation (1) makes use of division by $x - x_0$, an operation having no counterpart for vectors in a general vector space. However, equation (1) can be expressed in the equivalent form:

$$\lim_{x \to x_0} \frac{f(x) - f(x_0) - g_{x_0}(x-x_0)}{|x - x_0|} = 0. \tag{2}$$

The division by an absolute value introduced in this reformulation (and, more particularly, the absolute value itself) *does* have a vector space counterpart, whose description follows.

A *norm*, $\|\cdot\|$, is a real-valued function defined on a vector space and satisfying the following conditions (stated for arbitrary vectors x, y and an arbitrary scalar $r \in \mathbb{R}$): (1) $\|x\| \geqslant 0$; (2) $\|x\| = 0$ only if x is the zero vector; (3) $\|rx\| = |r|\,\|x\|$; (4) $\|x+y\| \leqslant \|x\| + \|y\|$. A norm is a kind of generalized absolute value for a vector space. Intuitively, $\|x\|$ is the distance between x and the zero vector, while $\|x-y\|$ is the distance between x and y.

Now, let V be a real-valued function defined on a vector space **V** equipped with a norm $\|\cdot\|$. (Functions of this type are often called *functionals*.) Then, we say V is *Fréchet differentiable at* $v_0 \in$ **V** if there exists a real-valued function Λ_{v_0}, both continuous (in the sense that $\|v-v^*\| \to 0$ implies $|\Lambda_{v_0}(v) - \Lambda_{v_0}(v^*)| \to 0$) and linear (in the vector space sense) on **V**, such that:

$$\lim_{v \to v_0} \frac{V(v) - V(v_0) - \Lambda_{v_0}(v-v_0)}{\|v - v_0\|} = 0. \tag{3}$$

We say V is *Fréchet differentiable* if it is Fréchet differentiable at v for each $v \in \mathbf{V}$. Observe that equation (3) is a direct parallel to equation (2).

The preceding definition provides a straightforward approach to Fréchet differentiability. However, just as in the definition of differentiability on the real line, slight modifications to the underlying assumptions are needed when V is defined only on a subset of **V**. This limitation on V is typical within expected utility theory, because utility functions for preference orderings are defined only on lottery spaces, and the latter, while *subsets* of a vector space (for example, the vector space of all linear combinations of c.d.f.'s), are not *themselves* vector spaces. We omit the complicating details. The essential point is that Fréchet differentiability at v_0 can be defined as long as (1) V is defined at all vectors near in norm-distance to v_0, and (2) Λ_{v_0} is linear and continuous over small (that is, small-norm) difference vectors of the form $v-v_0$, $v \in D_V$.

A statement of Machina's main result can now be given. Assuming $M > 0$, let L be the lottery space consisting of all c.d.f.'s on the closed interval [0,M] (that is, all c.d.f.'s L for which $L(0) = 0$ and $L(M) = 1$). Let $\|\cdot\|$ be the "L^1 norm" $L^1[0,M]$ (Kreyszig, 1978, p. 62), for which:

$$\|L-L^*\| = \int_0^M |L(t)-L^*(t)|\,dt,$$

whenever $L,L^* \in L$. (Note: the symbol "L^1" is standard and independent of our use of "L" to denote a lottery.) Let V be a Fréchet differentiable function defined on L. (Observe that V is automatically a utility function for the risk preference ordering $\succcurlyeq$ defined on L by: $L \succcurlyeq L^*$ if and only if $V(L) \geqslant V(L^*)$.) Then, for any $L_0 \in L$, there exists a function $U(\cdot,L_0)$: $[0,M] \rightarrow \mathbb{R}$ such that:

$$\lim_{\|L-L_0\| \to 0} \frac{V(L) - V(L_0)}{\int_0^M U(t,L_0)dL(t) - \int_0^M U(t,L_0)dL_0(t)} = 1.$$

Thus, when an individual moves from L_0 to a nearby lottery L, the difference in the V-utility values is nearly equal to the difference in the expected values of $U(\cdot,L_0)$ with respect to L and L_0. In this sense, the individual behaves essentially like an expected utility maximizer with "local utility function" $U(\cdot,L_0)$.

Machina also showed how various local properties (that is, properties of the local utility functions) can be used to derive global properties (that is, properties of the utility function V itself). In so doing, he demonstrated that many of the standard results of expected utility analysis remain valid under weaker assumptions than previously realized.

The applicability of Fréchet differentiation in economics is not limited to risk theory. For example, Lyon and Bosworth (1991) use Fréchet differentiation to investigate the generalized cost of adjustment model of the firm in an infinite dimensional setting. They call into question the acceptance within received theory of a disparity in the slopes of static and dynamic factor demand functions. Their results, if correct, would have implications for agricultural economics studies that have relied on the received theory to interpret their empirical findings (Vasavada and Chambers, 1986; Howard and Shumway, 1988).

Conclusions

The theory of individual choice under risk is a subject in ferment. Spurred on by the contributions of Machina and others, researchers are actively seeking an empirically more realistic paradigm to describe behavior under risk. Their search deserves the attention and participation of agricultural economists.

Today, the frontier of research on behavior under risk employs such mathematical tools as measure theory and functional analysis. Other techniques, including those of differential geometry (Russell, 1991), are on the horizon. What is certain is that the economic analysis of uncertainty is now drawing on technical methods of increased generality and sophistication.

Readers wishing to explore this subject further should benefit from the references already cited. In addition, a more extensive introduction to the contemporary, set-theoretic style of mathematical reasoning used in this article may be found in (Smith, Eggen, and St. Andre, 1986).

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